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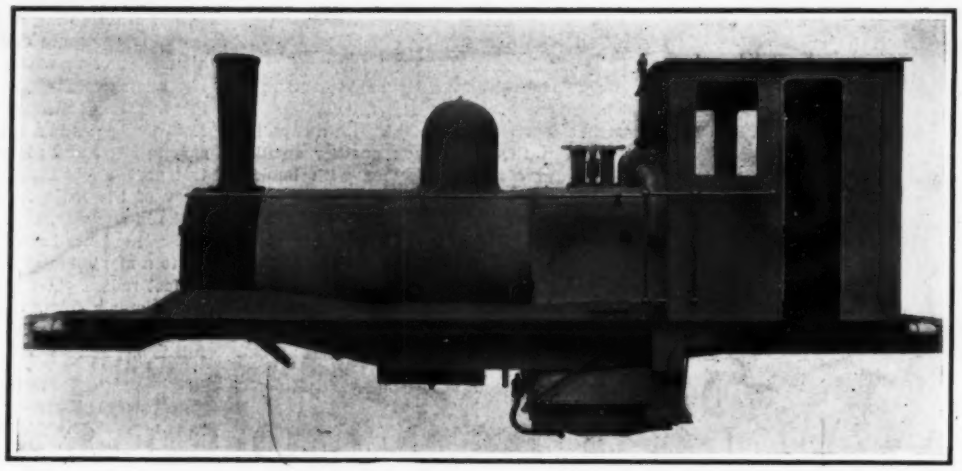
THE GARRATT FLEXIBLE RAILROAD LOCOMOTIVE.

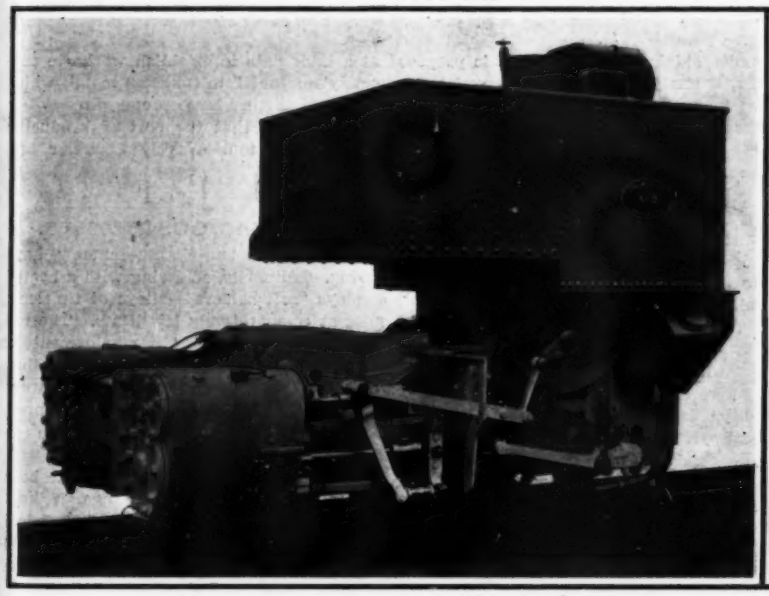
By the English Correspondent of the SCIENTIFIC AMERICAN.

THERE has been constructed at the Manchester locomotive works of Messrs. Beyer, Peacock & Co., Ltd., a novel type of locomotive. The general principle of this new type, which has been designed by Mr. H. W. Garratt, M. I. Mech. E., may be gathered from a reference to the accompanying illustrations. Its salient features are its extreme flexibility and adaptability to operation upon steep grades and sharp curves, combined with a maximum of adhesion effort.

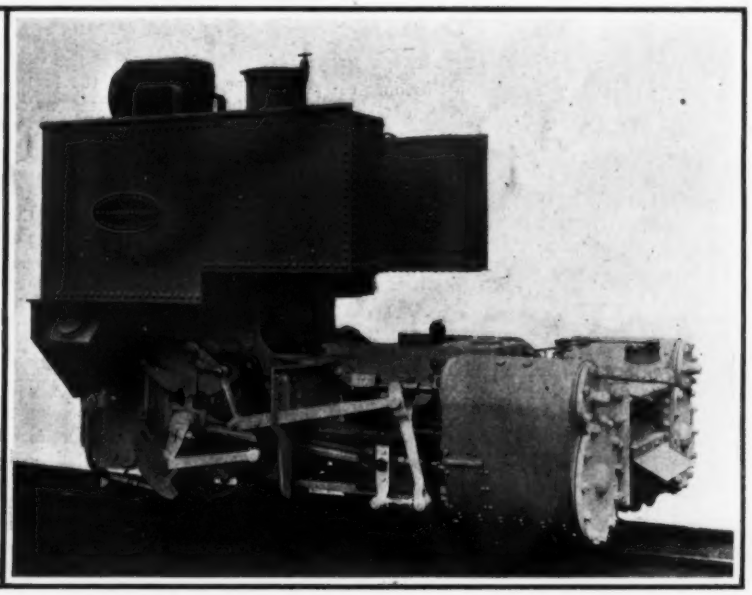


THE MAIN FRAME AND BOILER LIFTED CLEAR OF THE BOGIE TRUCKS.

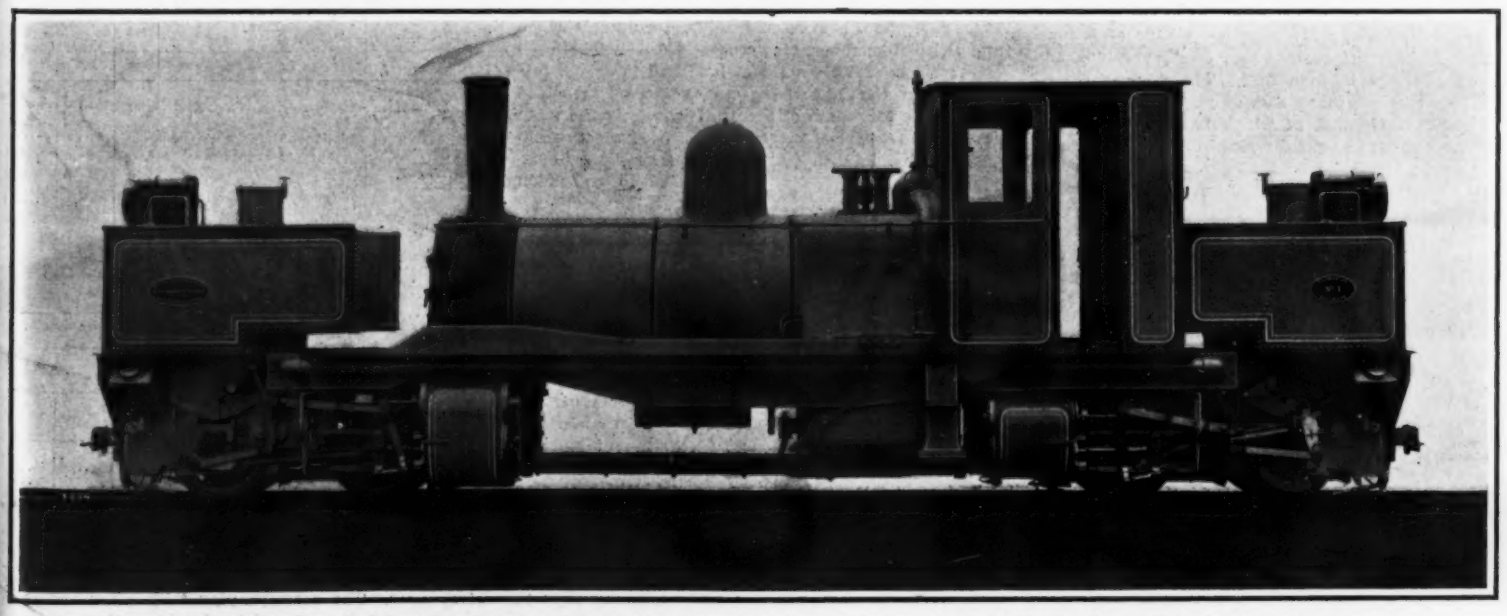
The engine broadly comprises three fundamental units, the boiler and frame, and forward and trailing bogies, respectively, which can be attached or detached from the boiler by means of couplings at either end of the main frame. The leading bogie is fitted with the low-pressure cylinders, while the trailing bogie is equipped with the high-pressure cylinders. This disposition, it may be pointed out, possesses many distinct advantages, for the boiler being centrally placed, may be brought fairly low, and the firebox may be made wide and deep, for



THE TRAILING BOGIE WITH HIGH-PRESSURE CYLINDERS, 300-GALLON WATER TANKS AND BUNKER FOR ONE TON OF COAL.



THE LEADING BOGIE WITH ITS 510-GALLON WATER TANK, SHOWING CONNECTIONS AND LOW-PRESSURE CYLINDERS.



FLEXIBLE LOCOMOTIVE, SHOWING ARRANGEMENT OF FORWARD AND TRAILING BOGIES, WATER AND FUEL TANKS, MAIN FRAME, AND BOILER.

THE GARRATT FLEXIBLE RAILROAD LOCOMOTIVE.

there is no hamper beneath the frame, such as axles, to restrict the boiler and firebox dimensions. Moreover, the width and length of the boiler are not placed within such severe limits as at present obtain, a feature which the locomotive engineer cannot fail to appreciate. Also, the whole weight of the engine is imposed upon the driving wheels, so that the maximum adhesion effort is secured. In negotiating curves, as the three parts of the engine move independently, the central part or main frame assumes a position analogous to the chord of the curve, and the center of gravity of the whole engine is brought inward. This enables far sharper curves than are possible with either duplex or articulated engines to be negotiated safely, and without any of the drawbacks incidental to the usual foregoing types, such as projection of the engine frame over the outer forward side of the front truck, which factor on sharp curves is responsible for certain difficulties in coupling and uncoupling operations. The two trucks accommodate themselves to the curve independently of the main frame, and as these carry the coupling arrangements, there is no more difficulty experienced on the minimum possible curve than upon a straight track.

The engine shown in the accompanying illustration is one of a pair that has been constructed for the 19-mile stretch of the Northeast Dundas 2-foot gage tramway of the government railroad of Tasmania. Owing to the severity of the grades and the numerous sharp curves which abound, certain factors to suit the prevailing conditions had to be taken into consideration, and the specification called for a compounding system, which tended to render the mechanism somewhat complicated. The system, however, is not necessarily a compound one, and consequently its design can, under ordinary circumstances, be simplified.

The boiler barrel mounted on the main frame has a length of 7 feet, with a diameter of 3 feet 11.125 inches. The heating surface is, tubes, 568 square feet, and the firebox, 60 feet, making a total of 628 feet, while the grate area is 14.8 square feet. The working boiler pressure is 195 pounds per square inch. The frame, built up of two main longitudinals, plates, angles, etc., is of rigid construction, the boiler being fixed at the smokestack end, while the usual provision is allowed for expansion at the firebox end. The two bogies have four pairs of wheels disposed in two coupled groups, and each group has a wheel base of 4 feet. The cylinders are placed outside the truck frames with valves on top, the gear being a modified Walschaert operated by a small return crank outside the main crank off the crosshead. The high-pressure cylinders on the trailing bogie have a bore of 11 inches by 16-inch stroke, the piston valves having inside admission, while the low-pressure cylinders on the forward bogie are of 17 inches diameter by 16-inch stroke, the steam admission being outside. The total wheel base of the engine is 26 feet 9 inches, and the over-all length 33 feet 10.5 inches, with a width of 7 feet.

The front truck carries a water tank with a capacity of 510 gallons, and the rear truck another smaller tank of 310 gallons capacity, together with bunker space for one ton of coal. With fuel and water tanks full, in running order, the total weight is 33 tons 10.75 hundredweight, divided as follows: Seventeen tons 5.5 hundredweight on trailing truck, and 16 tons 5.2 hundredweight on leading truck.

Owing to compounding, the steam arrangements are somewhat intricate, the steam being taken from the boiler to a point in front of the trailing truck to a ball joint exactly below the truck center, then for a short distance forward, where it is bifurcated and led to the high-pressure cylinders on either side of the truck. The exhaust from the cylinders is carried through a Y-pipe to a central ball joint, whence extends a longitudinal receiving pipe fitted with a sliding joint, to the forward bogie, where it is conveyed through another ball joint and intercepting valve by short branches leading to the cylinders on either side. The exhaust from the low-pressure cylinders is led off to a single pipe fitted with a ball and socket joint into another pipe having a sliding joint into the blast pipe. The intercepting valve on the leading bogie is controlled from the engineer's cab, so that when compounding the receiving pipe from the high-pressure cylinders is in communication with the low-pressure cylinders. In simple working the receiver is placed in direct communication with the blast pipe, as the steam passage to the low-pressure cylinders is closed by the intercepting valve, and live steam is supplied to the low-pressure cylinders. One reversing lever, by a simple motion, controls both bogies, and ample braking arrangements connected to both trucks are also fitted. The detachment of the main frame and boiler from the bogies is a simple operation. It is only necessary to disconnect pipes, rods, and so forth, lift the central part a few inches, and the truck can be pushed clear of the main frame without touching the truck tanks in any way.

These engines have been designed to work on grades up to a maximum of 4 per cent, and on curves of only 99 feet radius. The preliminary trials at the builders' works amply demonstrated the easy and steady riding of the engine. The coefficient of adhesion with tanks full is 5.3, and 4.5 with the tanks empty.

TUNGSTEN ORES.

HOW THEY ARE MINED IN SPAIN.

WORKINGS OF THE MINES AND USES OF THE METAL.

IN answer to an inquiry from a Pittsburg company, Consular Agent Harry A. McBride, of Bilbao, furnishes the following information concerning the tungsten mines of Spain:

The highly valuable form of tungsten ore known as wolframite is found in the Spanish provinces of Pontevedra, Corunna, Orense, Salamanca, and Caceres. A lower grade of tungsten is also found in the province of Cordoba, but in very small quantities.

Mines have but recently been opened, and the exportation of the ore began about 1903. Owing to the mountainous character of these provinces, the distance of the mines from the railroads, and the expense of machinery and fuel, the mining, in order to be profitable, must be done on a very large scale, and at present only one company (an English company) is working with modern machinery and raising important quantities of ore. This firm owns several mines in Pontevedra, Corunna, and Orense, the most important being the mines at Carbueira, Pontevedra, and those at Noya, Corunna. These mines produce from 200 to 300 tons of wolframite per year (about four-fifths of the entire Spanish output), all of which is exported to England. The other mines in these provinces are insignificant, producing annually from one to five tons.

The principal mines in Salamanca, the second of importance in Spain, are near the village of Barruecopardo in the northeastern part of the province, and are owned by a German firm. These mines extend over 590 acres of ground and, as yet, only the surface ore has been touched, of which from 40 to 50 tons have been obtained annually since 1904. This amount has all been bought by German firms. The production for the first two months of 1910 was 11 tons. Borings having been made to a depth of 98 feet and the richness of the territory proven, the firm is now endeavoring to secure sufficient capital, and estimates that about $43,000 will be necessary to properly work the mine.

MINOR OPERATIONS—QUALITY AND ANALYSIS.

Other mines in Salamanca are at Navasfrias, in the southwestern part of the province, very near the Portuguese frontier, from which about 20 tons in all have been obtained. There are several other small mines of very little importance. The principal mines of Caceres are in the northeastern part of the province, near the Navasfrias district, and only a few miles distant from Portugal. The annual production of the remaining mines of this province does not exceed two or three tons. The mines are small and owned by stock companies composed of large numbers of the farmers of that vicinity, who ask exorbitant prices for their shares, making exploitation almost impossible.

The quality of the wolframite obtained from these provinces is of the highest, and analysis of the ore, just as it is raised, averages from 60 to 65 per cent pure. In the form of concentrates, the average is from 68 to 72 per cent. Generally the ores from Northern Salamanca average the highest.

In combination with the wolframite from the provinces of Salamanca and Caceres, arsenical pyrites (mispickel) is found in large quantities. In the Navasfrias and Acebo mines the two minerals are so thoroughly mixed that it is necessary to burn out the arsenic in order to make the wolframite marketable. Farther north, in the Barruecopardo district, the formation is quite different. Here the arsenic is also found in large quantities, but it comes separated from the wolframite and makes a valuable addition to the products of the mines. Several tons have been exported at various times. Pieces of pure arsenical pyrites two feet square have been found here. In Pontevedra, Corunna, and Orense no arsenic is found, but quantities of tin are mixed with the wolfram ores.

The entire Spanish production of tungsten ores is exported, none being manufactured in this country.

Just over the Spanish boundary, in the Portuguese province of Biera Baja (Castelho Branco district, five miles from the town of Silvares), are located two important mines owned by a London company. This company was formed in 1908 with a capital of £100,000 ($486,650), and has erected mills, turbines, electric and gas plants, shops, etc., costing $90,000. The property consists of 1,256 acres of land and is only a few miles from the Navasfrias and Acebo mines. The quality and formation of the ore is precisely the same as that taken from the Spanish mines above mentioned. The following article, taken from the prospectus of this company, as published in a London newspaper, may be interesting:

WORLD'S OUTPUT OF TUNGSTEN AND ITS USES.

The world's output of high-grade wolfram ore is limited and is estimated to average about 4,000 tons over the past four years. Apart from the use of wolfram for chemical purposes, the demand for wolfram for the manufacture of high-speed tool steel is very large and steadily increasing. The use of wolfram steel for motor cars is becoming general in cars of high-class manufacture, particularly by the French makers. Wolfram is also used in the manufacture of electric lamps.

The manufacture of wolfram metal, which is also known by its trade name of tungsten metal, has been almost exclusively in the hands of German manufacturers; consequently the large English steel works manufacturing ordnance, gun forgings, armor plate, and high-speed tool steel and other forms of steel in which wolfram is employed have always had to depend on the foreigner for their supplies of metal. It is proposed at a later date to establish works to convert this company's output into tungsten metal, which should be a source of further large profits.

The article also states that the cost of producing wolframite is $272 per ton.—Weekly Consular and Trade Reports.

SOLDERS FOR VARIOUS METALS.

SOLDERING is divided into two classes—namely, hard and soft soldering. Ordinarily, soldering with a heated copper bit employs "soft solders"—alloys of tin, lead, etc., which melt at comparatively low heats. The use of the blowpipe makes possible the employment of "hard solders" which are alloys of silver, copper, zinc, etc., and melt at a very much higher temperature than the soft solders. The hard soldering of copper, iron, etc., is generally known as brazing, and the solder as spelter.

It must always be borne in mind that both soft and hard solders deteriorate with age, if kept for a long time in a damp atmosphere. For electrical work, ingredients such as mixtures of vaseline, rosin, glycerine, and chloride of zinc are used as non-corrosive fluxes. The accompanying table gives the composition of both soft and hard solders that are suitable for various metals.—A. Eyles, in Machinery.

Soft and Hard Solders for Various Metals.

Metal to Be Soldered.	Flux.	Soft Solder.		
		Tin.	Lead.	Other Constituents.
Aluminium	Stearin	70	—	Z* 25, A* 3, P* 2
Brass, Gunmetal, Copper	Chloride of zinc, rosin or chloride of ammonia	65 63 60	34 37 40	....
Lead	Tallow or rosin	33	67	...
Block tin	Chloride of zinc	99	1	...
Tinned steel	Chloride of zinc or rosin	64	36	....
Galvanized steel	Hydrochloric acid	58	42	....
Zinc	Hydrochloric acid	55	45	....
Pewter	Gallipoli oil	25	25	B* 50
Iron and steel	Chloride of ammonia	50	50	....
Gold	Chloride of zinc	67	33	....
Silver	Chloride of zinc	67	33	....
Bismuth	Chloride of zinc	33	33	B* 34

* Z = zinc, A = aluminium, P = phosphor-tin, B = bismuth.

Metal to Be Soldered.	Flux.	Hard Solder.			
		Copper.	Zinc.	Silver.	Gold.
Brass, soft	Borax	22	78	..	..
Brass, hard	Borax	45	55	..	..
Copper	Borax	50	50	..	..
Gold	Borax	22	..	11	67
Silver	Borax	20	10	70	..
Cast iron	Cuprous oxide	55	45	..	..
Iron and steel	Borax	64	36	..	..

REORGANIZATION OF AMERICAN FARMING.*

INTENSIVE CULTIVATION THE GOAL.

BY PROF. HOMER C. PRICE, OHIO STATE UNIVERSITY.

FROM the beginning, American agriculture has been characterized by its extensiveness rather than its intensiveness. Land has been more abundant than labor and, in the aggregate, more has been derived from a small yield on a large acreage than could have been realized from a large yield on a small acreage. The yields of American farm crops have been proverbially small, but the total production has been exceptionally large and, as a rule, the countries producing the largest amounts of farm crops have the smallest yields per acre. This fact is illustrated in the following table:

	Average Yield per Acre, 1888-1897.	Average Yield per Acre, 1898-1907.	Total Production.
	Bushels.	Bushels.	Bushels.
United Kingdom.....	30.1	33.6	55,585,000
Germany.....	22.7	28.4	138,442,000
France	17.6	20.8	310,526,000
United States.....	12.8	13.9	664,602,000

The above table also reveals the fact that the production per acre when compared by ten-year periods has been increasing in all the countries. Much has been said and is being written about the decline in agricultural production, but statistics do not show that there has been any decline, but rather a marked increase when the productions of the leading countries are compared and using the production of wheat, which is the most universally grown farm crop, as the basis for comparison.

The intensity of culture always bears a direct relation to the density of population, and while it is difficult to get a comparable basis of comparison between countries on account of the varying proportions of waste land in different countries and different methods of classifying statistics, the following table represents the most reliable figures available and, when compared with the preceding table, shows that the yield of wheat per acre varies directly as the density of population.

Number of Acres per Capita.

United Kingdom	1.70 acres.
Germany	2.37 acres.
France	3.40 acres.
United States (exclusive of Alaska and Philippines)	24.02 acres.

In 1900 there were 838,000,000 acres in farms in the United States, and since then we have been adding to them about 15,000,000 acres each year from the public lands of the country. During this time, however, the population of the country has been increasing at the rate of about one and one half million each year. The public lands of the country that are suitable for agricultural purposes have practically all been taken up; the tide of immigration has been turned back from the Pacific coast, and the competition for land already under cultivation has become much more keen and, as a consequence, the values of farm real estate have advanced generally throughout the country, but to the greatest extent in the western States. Farm lands in some sections have doubled or even tripled in value in the course of a few years.

Together with the increased value of farm lands have gone other changes that have had an important bearing on the agriculture of the country.

The development of methods of transportation and the extension of railroads through the new agricultural lands have widened the markets of the country, for both buying and selling. The introduction of refrigerator car service has made possible the shipping of fruits, meats and other perishable products across the continent. This has resulted in bringing the products of cheap lands in competition with the products of high-priced land in the eastern States.

Another factor that has had an important bearing in this connection has been the development of labor-saving farm machinery. If the present wheat crop of the United States were harvested by the method employed at the time of the civil war, it would require every man of military age in the United States to work for at least two weeks in wheat harvest. The invention of labor-saving machinery has increased the producing power of the individual to such an extent that notwithstanding the increase in the agricultural exports of the country from $205,853,748 in 1858 to $1,017,396,404 in 1908, the percentage of the population engaged in agriculture has decreased by decades as follows:

1880	44.3 per cent.
1890	37.7 per cent.
1900	35.7 per cent.

But notwithstanding the constant decrease in the proportion of the population engaged in agriculture, the per capita production for the entire population of the most important classes of agricultural products has increased almost invariably.

The following table gives the average per capita production by decades, 1866-1908. These statistics are from the United States Department of Agriculture:

Products.	Decade.				Period.
	1866-1875	1876-1885	1886-1895	1896-1905	1905-1908
Wheat, bushels.....	6.2	8.3	7.4	7.8	7.9
Corn, bushels...	24.6	30.3	27.5	28.4	31.8
Oats, bushels..... ..	6.9	9.1	10.7	10.6	9.8
Barley, bushels..... ..	0.7	0.9	1.1	1.3	1.9
Rye, bushels. ...	0.5	0.5	0.4	0.4	0.4
Potatoes, bushels	3.0	3.0	3.0	3.1	3.4
Cotton, pounds ...	37.8	51.4	57.8	65.5	70.0
Hay, tons.....	0.63	0.76	0.86	0.76	0.74
Horses, number ...	0.20	0.21	0.23	0.20	0.23
Milch cows, number..	0.25	0.24	0.25	0.22	0.24
Other cattle, number	0.37	0.47	0.55	0.49	0.55
Swine, number.....	0.69	0.75	0.73	0.58	0.64
Sheep, number.....	0.80	0.84	0.68	0.63	0.64

This almost inconceivable increase in agricultural production has been accompanied by changes in agricultural conditions that make a reorganization of American farming methods absolutely necessary.

Foremost among these changes has been the growth of cities from an urban population of 2,897,000, or 12.5 per cent. of the population total, in 1850, to a population of 24,992,000 or 33.1 per cent. of the total population in 1900. This concentration of the population has brought about new problems of food supply in furnishing the more perishable products such as milk, vegetables, fruits and such products as need to be consumed soon after production.

Another condition that has arisen is the tendency of the soil fertility of the farms of the older agricultural sections to become exhausted. To remedy this, the use of commercial fertilizers has become general in the eastern United States and the statistics of 1900 show that $55,000,000 worth of goods were used by the farmers of the United States, which was an increase of 42 per cent over the amount used in 1890, so that it is probable that not less than $75,000,000 per year is spent for this purpose.

The opening up of the Middle West took from the farmer of the eastern States his market for wheat and other grain. He was thrown in competition on the open market with the farmer who had secured his land for practically nothing and land that was much more fertile and productive. The farmer of the Middle West, in turn, has been thrown in competition in the live-stock markets with the live-stock products of the western and southwestern States and Territories. Stock that was raised under range conditions and often on government land free of charge competed with stock raised on high-priced farms of the Middle West.

While these conditions are not so emphatically true as they were a few years ago, yet the problem is far from being solved and the American farmer is now passing through a transitional stage and the most important problem before him at the present time is the question of reorganizing his farming methods so as to best fit the agricultural conditions as they now exist.

The unprecedented increase of values of farm products in recent years resulting in a greatly increased cost of living to every one has resulted in the most prosperous times the American farmer has ever experienced, except during the civil war by those who stayed at home and reaped the benefits of high prices.

The consumer, on the other hand, is alarmed at the continued rise in price of the necessities of life. He is interested in knowing what the end is going to be and how much longer prices are going to rise.

Writers who are ill-advised of the potential producing power of American farms are freely predicting that we are rapidly approaching the time when as a nation we shall not be able to produce sufficient food stuffs for our own population. They forget that our farms are not producing more than one-half of what they are capable of doing. Our average wheat yield is 14 bushels per acre; our average yield of corn is 26 bushels, and of oats, 25 bushels; these yields can and will be doubled in the future as the high price of the products will demand.

The profits of farming in the past gained from actual production have not been in proportion to the profits derived from other industries. The market price of farm products has tended toward the actual cost of production of the average crop at current wages rather than the cost of production of the part of the crop produced under the most unfavorable conditions. This is readily demonstrated by taking the actual amount of time required to grow and harvest an acre of any of the principal crops and calculating the time at current wages and the average yields at farm prices.

The results will show that the returns received for the time spent will not be more than enough to pay current wages and six per cent interest on the investment in land and equipment. Farmers have received greater returns from the increased value of their lands than they have from the profits upon their productions.

The increased prices of farm products are beginning to bring to farmers a just return for labor expended and will do more than anything else to turn the city dweller "back to the soil" and to keep the country boy on the farm. There is no danger of a shortage of food supplies in this country, but higher prices must prevail in order to develop the potential agricultural resources of the country. Aside from the possibilities of doubling the present crop production on present area under production, there remains the undeveloped agricultural lands of the country. Aside from the limited amount of land suitable for agricultural purposes remaining in the ownership of the government, the lands that may become valuable for agricultural purposes are of two kinds—the swamp lands that may be reclaimed by drainage and the arid lands that may be reclaimed by irrigation. The United States Geological Survey estimates that 75,000,000 acres can be made valuable for agriculture by drainage swamps. This is the equivalent of one-sixth of all the land now under cultivation in the United States. This land would be much more fertile and much more productive than the most of the land that is now being cultivated. The reclamation of arid lands is just in its infancy. The first federal act to provide for government assistance for this purpose was passed in 1902.

Projects are now under construction or have been completed that will reclaim one and a half million acres and others are under consideration that will reclaim three and one-half million. To what extent this work of reclamation will be carried in the future can scarcely be estimated, but doubtless many millions of acres can be and will be added to our cultivable lands in the future.

The period of low prices for farm products and extensive methods of farming is rapidly passing. The large grain and live-stock farms of the eastern States are giving way to the smaller dairy, fruit, vegetable or poultry farm. The large wheat farms of the Northwest are being divided into moderate-sized farms for mixed farming. The ranges of the West and Southwest are being broken up into stock farms, and the movement everywhere is toward more intensive methods of farming.

The problem that now confronts the American farmer is to reorganize his method of farming so as to adapt it to the present conditions. The increased prices for farm products will increase their production and insure a supply sufficient for all needs for the future.

* Popular Science Monthly.

The new Japanese law for the encouragement of native shipbuilding came into operation with the beginning of this year, and includes provisions according to which in the construction of the hull or the machinery for a vessel which is to receive a subsidy, foreign-made materials must not be used except for the following parts, viz.: Stem, stern post, rudder and rudder tiller, rudder post, quadrant and rudder pintles used for vessels of 3,000 tons or more; triple screw shaft bearing; stanchions of not less than 7 inches diameter; all kinds of springs; corrugated and plain or flanged furnaces; rotor spindle or shaft, blades and buckets of turbine engine. The following articles used in the equipment of a vessel which is to enjoy the subsidy must not be foreign made, viz.: Windlass, cargo winches, steering engine and gear, anchor chains, wire ropes, hawsers, etc., centrifugal pumps, hand pumps, fire pumps, boat and other davits, electric apparatus, auxiliary condenser, steam pumps, dynamo, valves and cocks. Patented articles or articles of new design made abroad can only be used in the construction of hull or machinery or in the equipment of a ship receiving a subsidy with the special permission of the Minister of Communication.

REMARKABLE COMETS.*

COMETS OTHER THAN HALLEY'S.

THE comets which might be included in a list with the adjective "remarkable" attached to it are very numerous; and I shall for the most part treat the word "remarkable" as applying rather to naked-eye peculiarities and splendor than to physical peculiarities revealed only by the use of the telescope. I must, therefore, limit myself to a selection, premising that Grant included the following as proper to be classed as "remarkable":

1066	1531	1682	1823
1106	1556	1689	1835
1145	1577	1729	1843
1265	1607	1744	1858
1378	1618	1759	1861
1402	1661	1769	
1456	1680	1811	

Grant's list was, if I remember right, put forth in a lecture which he gave at the Royal Institution in 1870, and the additions which should be made to it to represent the period 1870-1909 are singularly few, the chief of them being the comet of 1874 (iii.), best known as Coggia's comet; and the comets of 1881 (iii.), and 1882 (iii.); but the large comets which appeared in the Southern Hemisphere in 1880 (i.), 1887 (i.), and 1901 (i.) have some claim to notice. By the law of averages a good bright comet is now more than overdue, and it remains to be seen whether Halley's, when it attains its brightest development in 1910, will come up to the required standard.

The extravagant language used by the old writers, and the *bizarre* character of the drawings which they have left behind them, render it doubtful how far it is wise to attempt to reproduce either their words or their pictures. I will therefore start no farther back than the middle of the eighteenth century in my endeavor to present the reader with authentic information and authentic pictures of some comets of special importance.

Although it is commonly considered that Donati's comet of 1858 (presently to be described) is the most beautiful (though by no means the largest) on record, I cannot help thinking that De Chéseaux's comet of 1744, with its many and very large tails, should receive the palm for striking beauty. The recorded descriptions of these tails are, however, not very detailed.

This comet was long under a cloud (metaphorically), because nobody seemed inclined to believe that the only drawing and description of it, with its six tails, known till recently to be extant, could be true, depending as it was supposed to do on the testimony of one man, and he of no particular astronomical standing, while other astronomers of repute mentioned the comet, but made no allusion to its many tails. However, all distrust of this man's honesty must now be regarded as unreservedly withdrawn, ample confirmatory testimony having been brought to light as recently as 1864.

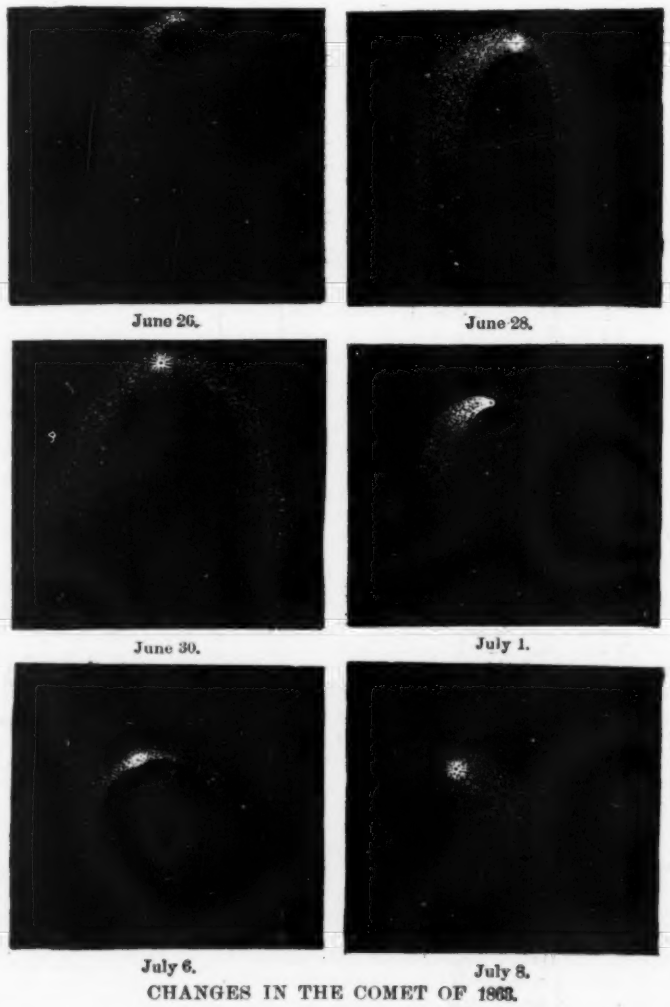
COMET A, 1910.

The circumstances under which this came about are sufficiently curious. Winnecke, in the year named, unearthed at St. Petersburg some records of MS. by the French astronomer Delisle, in which the fact of this comet having had several tails was clearly stated. He also found in an anonymous pamphlet printed at Berlin in 1744, and edited, it would seem, by the well-known mathematician, L. Euler, a very detailed description of the comet and its multiple tail, fully confirmatory of De Chéseaux's account, and written by a lady member of a well-known German astronomical family, Fräulein Margaretha Kirch.*

De Chéseaux has left the following description (translated from the French) of this comet:

"It appears certain from all the observation up to March 1st, that if this comet had appeared under more favorable circumstances, e. g. in the middle of a night instead of so near the setting sun, and also clear of moonlight, it would have been a more striking comet than had ever been known, alike from the size of its head, and from the length of its tail, which up to this time had been simply double; but something much more surprising was in store for us. The sky was quite overcast from the 1st to the 7th of March, but on this last-named day the clouds became broken and gave us some hope of seeing the comet's tail. I prepared myself for seeing over again just about what I had seen during the closing days of February. At 4 o'clock on the morning of March 8th, I went downstairs with a friend into the garden with the east facing us. This friend walking in front of me startled me by saying that instead of two tails there were five. I hardly believed him, but after having passed from behind several buildings which had partly concealed the eastern horizon from me, I did indeed see five tails in the form of whitish rays lying one above the other obliquely above the horizon up to a height of 22 deg., and of about the same breadth in all. These rays were each about 4 deg. in width, but they became narrower toward their lower extremities. Their edges were sufficiently distinct and rectilinear. Each ray was made up of three bands; the middle one was darker, and double the width of the bands forming

DONATI'S COMET OCTOBER 5 AND 9, 1858.



CHANGES IN THE COMET OF 1868.

* "The Story of the Comets Simply Told for General Readers." By George F. Chambers, F.R.A.S. Oxford: at the Clarendon Press. 1909.

* All this story is fully set out by J. W. L. Dreyer in the Copernicus Magazine, vol. iii., p. 104, 1884, accompanied by diagrams.

the edges. These last named resembled precisely the brightest portions of the Milky Way between Antinoüs and Sagittarius, and between Ophiuchus and Scorpio. The interval between the chief rays was dark like the

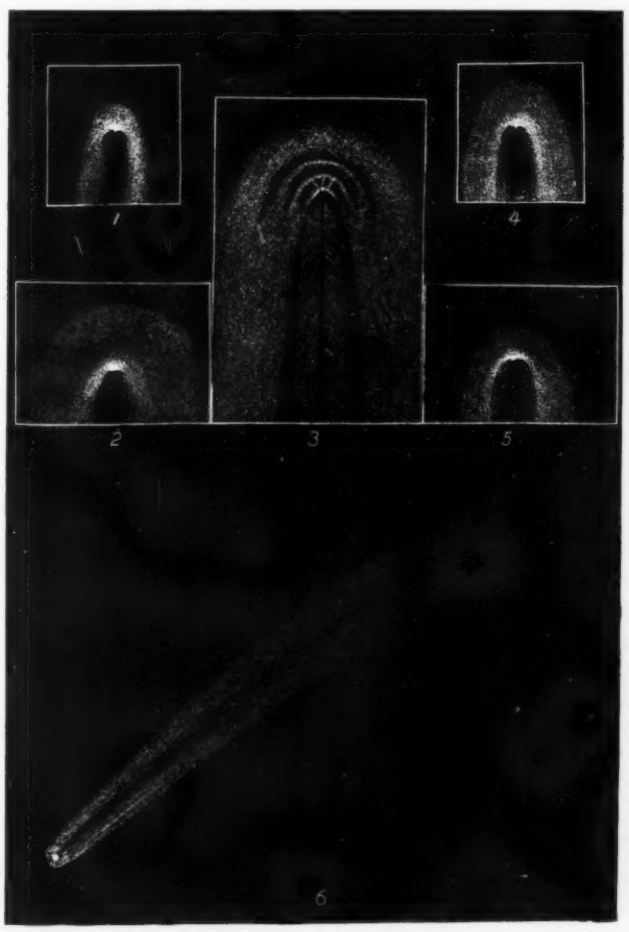
COGGIA'S COMET, 1874, ON JULY 13.

rest of the sky; however, at the bottom there was some luminosity resembling that at the extremity of these rays, as if we were looking at the tips of other rays of shorter length. Besides these five tails edged by white bands there was a sixth in which one noticed no bands, perhaps because it was low down. This sixth tail joined to the ten brighter bands of the others presented the appearance of there being eleven rays in all."

De Chéseaux goes on to make some comments which seem rather intended as a reply to certain persons who had criticised unfavorably the idea that the object which they had been looking at was really a comet. After referring to the fact that eighteen persons had seen the comet at Lausanne, and several at Berne, but that bad weather had prevented any observations at Geneva or Paris, he says: "Astronomers must judge for themselves whether the phenomenon described was that of a celestial body; and if it could have been possible that any merely atmospheric phenomenon could have maintained steadily during twenty-four hours its condition unchanged, its size and color the same, its position with respect to the fixed stars the same, and have participated with them in the diurnal movement." De Chéseaux reckons his twenty-four hours from the night of March 7th and 8th to the following night of March 8th and 9th, after which he never saw the comet again. He adds that "the sky was very serene without the least cloud or haze, and that both sun and moon (to one or other of which only could the phenomenon be ascribed if it was only atmospheric) were both of them too far away from the point of convergence of the tails." He then offers some further remarks directed to show that if the rays were tails of a comet, which had its head below the horizon, everything would be explained satisfactorily.

The comet of 1811 (I.), is one of the most celebrated of modern times. It was discovered by Flaugergues at Viviers on March 26th, 1811, and was last seen by Wisniewski at Neu-Tscherkask in the south of Russia on August 17th, 1812, a visibility of seventeen months—a period then unprecedented. It was a result of this long visibility that owing to the earth's annual motion, the comet twice disappeared in the sun's rays, and twice reappeared after having been in conjunction with the sun. In the autumnal months of 1811 it shone very conspicuously with a bright nucleus and tail, which became visible soon after sunset and continued visible throughout the night for many weeks, owing to its high northern declination. The extreme length of the tail is dated for the first week in October, and was about 25 deg., with a breadth of about 6 deg.

Previously to this, in August, the tail, according to Bouvard, was divided into two branches which were nearly at a right angle to each other. Sir W. Herschel paid particular attention to this comet, and his observations are of great value. He states that it had a well-defined planetary disk by way of nucleus, which was involved in the nebulosity forming the head. From this measurement he calculated that the diameter of the nucleus was 428 miles. When examined with high powers the stellar character of the nucleus



DONATI'S COMET, 1858, AND VIEWS OF THE COMA.

disappeared, and the light was spread, though not uniformly. The nucleus had a ruddy hue, but the surrounding nebulosity was of a bluish-green tinge. The real length of the tail about the middle of October was upward of 100,000,000 miles, and its breadth about 15,000,000 miles. This comet is undoubtedly a periodical one. Argelander, whose investigation of the orbit is the most complete, assigned to it a period of 3,065 years, subject to an uncertainty of only forty-three years. The aphelion distance is fourteen times that of Neptune, or, say, 40,000,000,000 miles.

The comet of 1843 (I.) was another very celebrated comet, and I once came upon the following remarks made by one who had seen Donati's comet of 1858, as well as that of 1843, and was able to compare the one with the other. Gen. J. A. Ewart wrote thus of the comet of 1843:

"It was during our passage from the Cape of Good Hope to the equator, and when not far from St. Helena, that we first came in sight of the great comet of 1843. In the first instance a small portion of the tail only was visible, at right angles to the horizon; but night after night as we sailed along, it gradually became larger and larger, till at last up came the head, or nucleus, as I ought properly to call it. It was a grand and wonderful sight, for the comet now extended the extraordinary distance of one-third of the heavens, the nucleus being, perhaps, about the size of the planet Venus."

Gen. Ewart thus speaks of Donati's comet of 1858:

"A very large comet made its appearance about this time, and continued for several weeks to be a magnificent object at night; *it was, however, nothing to the one I had seen in the year* 1843, when on the other side of the equator."

Writing from the Cape of Good Hope on November 12th, 1843, to his friend Admiral Smyth, Mr. (afterward Sir Thomas) Maclear said:

"Of the casual observatory phenomena, the grand comet of March takes precedence; and few of its kind have been so splendid and imposing. I remember that of 1811: it was not half so brilliant as the late one."

So far as I know this is the only account which has ever appeared in print, written by one who had had the chance of seeing both comets, and was capable of scientifically appraising them. Sir John Herschel would have seen all three of these bodies (1811, 1843, 1858), but he does not appear to have left behind him any remarks on the earliest one. This may not be extraordinary, seeing that he was only an undergraduate at Cambridge, and only aged 19 when the comet appeared, and that he did not start his astronomical career until five years afterward. The comet of 1843 was first seen in the Southern Hemisphere in the last week of February, but nobody can be named as its first discoverer, because it displayed itself suddenly, and was seen by a multitude of persons. During the first fortnight in March it shone with great brilliancy, and the journals of Australian and New Zealand colonists make many allusions to it. It was not visible in England until after March 15th, when its splendor

had much diminished, but the suddenness with which it made its appearance to observers in the Northern Hemisphere, as it had done in the Southern, added not a little to the interest which it excited. The general length of the tail during March, as seen in the Northern Hemisphere, was about 40 deg., and its breadth about 1 deg.

The orbit of this comet is remarkable for its small perihelion distance, which according to the most trustworthy calculation did not exceed about 500,000 miles; and the immense velocity of the comet in its orbit when near perihelion occasioned some extraordinary peculiarities. Thus, between February 27th and February 28th it described upon its orbit an arc of no less than 292 deg. Assuming its true orbit to be elliptical, as we are entitled to do, this would leave only 68 deg. to be described during the time which would elapse before its next return to perihelion. Various attempts have been made, without any very definite measure of success, to identify this comet with others which have gone before; but this is a matter which belongs to a previous chapter.

The comet of 1858 (vi.). On June 2nd in that year G. B. Donati, of Florence, descried a faint nebulosity slowly advancing toward the north, and near the star λ Leonis. Owing to its immense distance from the earth (something like 240,000,000 miles) great difficulty was experienced in laying down its orbit. By the middle of August, however, its future course, and the great increase in its brightness which would take place in September and October, were clearly foreseen. Up to August it had remained a faint object, not discernible by the unaided eye. It was distinguished from ordinary telescopic comets only by the extreme slowness of its motion (in singular contrast to its subsequent career), and by the vivid light of its nucleus. It has well been said that "the latter peculiarity was of itself prophetic of a splendid destiny." Traces of a tail were noticed on August 20th, and on August 29th the comet was faintly perceptible to a keen unaided eye, but it was not until September 3rd that I so saw it. For a few weeks the comet occupied a northern position in the heavens, and it was therefore seen both in the morning and in the evening. On September 6th a slight curvature of the tail was noticed, which subsequently became one of the most striking features. On September 17th the head equaled in brightness a star of the 2nd magnitude, the length of the tail being 4 deg. The comet passed its perihelion on September 29th, and was at its least distance from the earth on October 10th. Its rapid passage to the Southern Hemisphere rendered it invisible in Europe after the end of October, but it was followed at the Santiago-de-Chili and Cape of Good Hope observatories for some months afterward, being last seen by Sir T. Maclear at the latter place on March 4th, 1859. Its early discovery enabled astronomers, while it was yet scarcely distinguishable in the telescope, to predict, some months in advance, its approaching brilliancy, and thus the comet was observed with all the advantage of previous preparation and anticipation. "The perihelion passage occurred at the most favorable moment for presenting the comet to good advantage. When nearest the earth the direction of the tail was nearly perpendicular to the line of vision, so that its proportions were seen without foreshortening. Its situation in the latter part of its course afforded also a fair sight of the curvature of the train, which seems to have been exhibited with unusual distinctness, contributing greatly to the impressive effect of a full-length view." This comet, though surpassed by many others in size, has not often been equaled in the intense brilliancy of its nucleus, and the unusual, and, so to speak, artistic conformation of its tail, which features the absence of the moon in the early part of October enabled spectators to view to the very best advantage. The passage of the comet in front of Arcturus on October 5th will ever remain treasured in the memory of those who saw it. There is no doubt that Donati's comet revolves in an elliptic orbit, the period of which has been variously estimated at 1879, 2040, and 2138 years, and Kritzinger thinks it may be identical with a great comet which is recorded by Seneca as having appeared in B. C. 146, and dated by the Chinese for the month of August in that year.

The head of Donati's comet deserves some special description because of the changes which it underwent and which have already been mentioned as features which often characterize very large comets. Bond first noticed, on September 20th, envelopes, two in number, above the nucleus, the outer one at a distance of 16 seconds above the nucleus, and the inner one about 3 seconds. The outer one disappeared on September 30th at the height of about 1 minute. Meanwhile a third had appeared, the one originally second having gradually expanded so as to take the place of the first. Seven successive envelopes in all were seen to rise from the comet, the last one starting on October 20th, when all the others had been dissipated. It was calculated that the envelopes moved upward at the general rate of something like 30 miles an hour. The first one rose to a height of about 18,000 miles, when it wasted away; but none of the others reached so far, disappearing at elevations lower and lower, the last being lost sight of at an elevation of about 6,000 miles.

The following is a table of the dimensions* of the comet's nucleus and tail, at the undermentioned dates:†

Date. 1858.	Diameter of Nucleus. " Miles.	Length of Tail. ° Miles.
July 19 ..	5 = 5,600	..
August 30 ..	6 = 4,660	2 = 14,000,000
September 8 ..	3 = 1,980	4 = 16,000,000
" 12 ..	..	6 = 19,000,000
" 23 ..	3 = 1,280	5 = 12,000,000
" 25 ..	..	11 = 17,000,000
" 27 ..	..	13 = 18,000,000
" 28 ..	..	19 = 26,000,000
" 30 ..	..	22 = 26,000,000
October 2 ..	..	25 = 27,000,000
" 5 ..	1.5 = 400	33 = 33,000,000
" 6 ..	3.0 = 800	50 = 45,000,000
" 8 ..	4.4 = 1,120	50 = 43,000,000
" 10 ..	2.5 = 630	60 = 51,000,000
" 12 ..	..	45 = 39,000,000

It has been calculated that at perihelion Donati's comet travels at a speed of 30 miles a second; but that at aphelion its speed is only 234 yards a second.

(To be continued.)

* These measurements must be read in the light of the caution that all dimensions given in miles depend on the old value (8.57") of the sun's parallax. The probable value is now regarded as 8.8".

† G. P. Bond, Math. Month. Mag., Boston, U. S., Nov. and Dec. 1858. Bond subsequently published a magnificent volume of notes and pictures relating to this comet forming vol. ii of the Annals of the Harvard College Observatory. Cambridge, Mass., 1862.

THE BODY'S GROWTH.*

SOME INTERESTING PHASES.

In one of his ironical moments Hazlitt has written, "If you do not know the muscles by the help of which you walk, how is it you do not fall down at every step you take?" The paragraph in which this sentence occurs was written by Hazlitt to emphasize the importance of intuition as contrasted with reason in the general conduct of life. But there can be little doubt that a scoffing sentence of a similar sort might be written to indicate the attitude of mind that most people adopt toward what is supposed to be peculiarly scientific information. It is indeed remarkable how very reluctantly scientific knowledge is adopted as a factor in their mental development by those whose education does not terminate abruptly when they leave school. The changes that have been introduced into our methods of education, as a consequence of more enlightened ideas regarding the art of teaching, have not been altogether free from mistake; and even the present generation stands under the reproach of Herbert Spencer, who declared that "men who would blush if caught saying Iphigénia instead of Iphigeni'a, or would resent as an insult any imputation of ignorance respecting the fabled labors of a fabled demigod, show not the slightest shade in confessing that they do not know where the Eustacian tubes are, what are the actions of the spinal cord, what is the normal rate of pulsation, or how the lungs are inflated." But probably the diffidence with which a layman approaches a subject of a scientific nature is a result of that strange and formidable vocabulary that necessarily grows around any specialization of knowledge; and had these notes been entitled "An Outline of Postembryonic Ontogeny" I question if any editor of a general magazine would have deigned to consider even the first of my sentences.

I have chosen the simple title above, not as a subterfuge to lure the editor, but as an indication of the manner in which I propose to relate a few of the changes that take place in the human body in the course of its growth toward maturity. Certain of these changes are of great interest to the general reader, and it is my aim here to give a short account of them in ordinary language.

Many readers of this article will be able to recall to mind that masterpiece of ancient statuary, the group of the Laocoön, where a father with his two sons is crushed to death in the folds of two gigantic serpents. To judge from the difference in height between the father and his sons, the figures of the latter are meant to depict mere boys. Yet there is nothing boyish about the figures. They are only diminutive men, and one receives the impression that the master who gave this wonderful group of statuary to the world was in the habit of thinking of children as men in miniature. But even those who realize that a man or a woman is not merely an enlarged child seldom fully appreciate the extent to which the growth of the body is a process of metamorphosis. In respect of at least one organ, the mature individual has lost something of the physical endowment with which he entered the world. When a child is born its little chest contains a bulky organ of which grown men and women can show but the merest trace. It is the thymus gland; it lies just over the heart, and is a double-lobed body of a pinkish color. In a baby this gland is generally large enough to extend from the heart up to the neck. When the baby has completed its second year the gland begins to diminish in size, and continues to shrink gradually but slowly. During childhood the thymus remains a gland of some size, but it meets with misfortune about the age of thirteen or fourteen. At that age it begins a rapid career of degeneration; and, although it does not disappear entirely, it is represented in an adult by an insignificant remnant.

The thymus gland is an instance of *absolute* diminution in the bulk of an organ with the passing of the years. But during the body's evolution toward maturity instances occur of *relative* diminution in size, and of that phenomenon the liver is perhaps the most interesting example. The liver of a full-grown person generally weighs about three pounds, and as a rule an adult weighs about forty times the weight of his liver. But the liver of a newly born baby is *relatively* a bulkier organ. So large is the liver of an infant compared with its tiny body that one may safely say its whole body-weight is seldom more than twenty times that of its liver. This disproportion is still more remarkable when we bear in mind that a baby is normally fatter than a man. A baby is, in fact, a very corpulent person; and if we remained as obese throughout our lives as most of us are when we set out on our careers we should indeed have fat men about us, if not "such as sleep o' nights." The plumpness of a baby is not without meaning. It recalls the far-away epoch in the history of our race when the vicissitudes of early life were even greater than they are to-day, and only that sort of baby that came into the world with a good reserve of fat would be proof against the troubles that beset the first years of life. Where babies are born into a community that rejoices in a profuse supply of patent foods an abundance of fat is not of such paramount importance; but from an æsthetic point of view the chubby baby will continue to command our admiration.

In any case, it is certain that our ideas regarding the correct proportions of the human body will always place upon our babies the duty of hastening to increase the length of their legs. It is known to the privileged who have beheld a newly born child *en déshabillé* that the little legs are very short in proportion to the length of the trunk; but probably the very observant are the only ones who know that a baby's legs measure but one-quarter of its length, whereas a man that has grown to maturity owes one-half of his height to the length of his legs. But, even in the interval that elapses between birth and the first attempts to walk, a baby will reduce this disproportion to a very considerable extent. Indeed, a rapid growth of the lower limbs is a feature of early life; and a child of three is already half as tall as it is ever likely to be.

During the years of childhood boys and girls increase their heights at the rate of two inches each year; but this rate of increase is subject to variations according to the season of the year and to many other conditions. The greatest variation of this rate of increase occurs at fixed and definite periods for each sex. In the case of girls the eleventh year is generally a year of sprouting, and a little more than two inches is usually added to the height. This annual rate of increase may be continued until the fourteenth year, and from that year to the seventeenth the annual increase is comparatively little. It is very seldom that a girl adds anything to her height after the seventeenth year. With boys the sprouting period is generally postponed until the fourteenth year, and

* Chambers's Journal.

it lasts with them until the seventeenth year. During these three years two and a half inches are often added to the height each year, but after the seventeenth year the annual increase is seldom more than a quarter of an inch. The twentieth year or the twenty-first is, as a rule, the last of the years in which youths may add to their height. Although the "dates" of these changes are remarkably universal, these measurments, and also the ages that have just been mentioned, are of course subject to slight variations in different individuals; and this remark will apply to any "dates" that may be mentioned in the following paragraphs.

In the remarkable growth of a child's lower limbs the thigh is the segment that grows most rapidly, but in the case of the upper limbs it is the forearm that is most active in growth. From an æsthetic point of view this needs must be so; for the hand of a newly born baby is generally a little longer than its forearm. But then babies' feet and hands are always disproportionately large. If a man's feet were as long as the upper part of his arm we should count him a man of very large feet. Yet careful measurement reveals the fact that the feet of most newly born babies are just about as long as their upper arms. If a mature man wishes to realize the changes that have taken place in his proportions since babyhood, he may contemplate his shapely figure, and safely say that his legs are five times as long as they were to start with, but his hands are only three times the length of his baby-hands.

All increase in the bony framework is brought about by a process that is somewhat involved. The process is one in which bone gradually takes the place of gristle, and this conversion of gristle into bone goes on very generally throughout the skeleton. But an exception exists in the case of the bones that form the skull and most of the bones of the face. The skull bones and many of the face bones are not formed from gristle but from fibrous membranes. So it comes about that when a baby is born its cranium is not formed entirely of bone. There are six distinct islands of membrane on the head of a newly born child, and it is only in the second year of life that bone replaces these areas of membrane. The largest boneless area can be felt on the top of any tiny head that is less than a year or eighteen months old; and frequently a line can be felt running straight down the forehead where the two portions of bone have not yet fused into one; a line that is sometimes palpable throughout the whole of life.

There are few structures in which the adult differs from the infant more than in the skull. It is obvious to everybody that the skull of a baby is exceedingly large in proportion to the size of its face. But the differences between the immature skull and the skull of a fully grown man are far too numerous and too intricate to deal with here in detail.

It is, however, worth while to mention one or two characteristic differences between the skull of an adult and that of a child. One sometimes speaks of the forehead and the brow as though the words were synonymous. General usage knows no difference between the forehead and the brow. But probably the English word brow was originally applied only to the prominent ridge over the eyes. The Miltonic Satan, who "with contemptuous brow" addresses the Angel Gabriel, makes us think, not of a wrinkled forehead, but of the elevated eyebrows that produce a look of contempt. At least, to the anatomist, there is a difference between that part of the skull which lies just over the eyes and the rest of the forehead. In many well-developed men it can be observed that the part of the forehead immediately over the eyes is characterized by a distinct slope for about half an inch. This obliquity is caused by the formation of air cavities in the bone. These cavities are less developed in women than in men, and the absence of this slope gives the foreheads of women a "nobler" aspect than those of men. But we are not born with these cavities in our skulls. A child does not show them until it has entered its second year, and during childhood they develop but slowly. About the fifteenth year they increase more rapidly, and they continue to enlarge for many years, so that in advanced life they are sometimes of considerable size. Air cavities are formed also in a bony prolongation of that hard lump which everybody may feel behind the ear. This bony prolongation is taking shape about the fifth year of life, and the air cavities make their appearance in it during the eventful fifteenth year.

Alterations in the skull naturally suggest questions regarding the growth of the brain. The period of life in which the brain adds most to its weight is between birth and seven years of age. From seven to fifteen the brain still adds to its weight, but at a slower rate than during the previous period. From this period of life the brain increases its weight but slowly. Still, in most cases the brain does not attain its maximum weight until the age of forty. After forty the brain loses about one ounce of its weight in the course of every ten years; but this loss of weight is not directly associated with any loss of intellectual strength.

The careful reader must have observed how frequently it has been necessary to mention the period of life about the fifteenth year in connection with changes in the body. These profound changes are heralding the approach of that period when parentage becomes a possibility. It is as though the body, hitherto concerned in knitting itself more firmly together, were beginning to realize that such a thing as parentage exists, and that it is an affair of some importance, requiring considerable preparation. Only those who are accustomed to think of the human body from a biological point of view can fully realize the amount of preparation it makes for the gallant time of courtship. The first inclination to go a-wooing generally asserts itself, more or less modestly, about the age of sixteen. When referring to the effect which this event has upon the growth of the body, the German biologist Haeckel writes in these terms: "It is one of the chief mechanical causes of the highest development of life, and throughout the whole of nature the greatest effects proceed from this very small cause." This period in the life of the developing organism is characterized by the changes of great interest; but, with the reproving countenance of the editor ever present to one's mind, one dare not occupy more space than will be required to explain the "breaking" of a boy's voice about his fourteenth year. The voice, as everybody knows, is produced by vibrations of the vocal cords. The cords extend from before, backward, inside the larynx. The larynx or voice-box is composed of several pieces of gristle connected by small muscles. The two largest pieces of gristle can be seen in adult men projecting from the throat as Adam's apple. It would prolong this article unduly were I to enter in detail into all the changes that take place in the growing larynx while the voice is developing from the high-pitched squeak of the infant to the sweet tones of a woman's voice, or the deep, loud voice of a man. I am at present concerned only with the change from the "childish treble" to the "big, manly voice"; and it will suffice if I remind the reader that the pitch of the voice depends upon the length of the vocal cords (the longer the cords are, the lower is the pitch), and that the length of the cords depends upon the distance between the back and front of the larynx. It can, then, be easily understood that the pitch of the voice ultimately depends on the growth of the pieces of gristle forming the larynx. Now, the growth of these pieces of gristle is not uniform throughout life. Between the seventh and the fourteenth year the larynx grows but very little. About the fourteenth year the pieces of gristle suddenly throw off their torpor and begin to grow with astonishing rapidity. So rapid is the growth of a boy's larynx at this period that the unfortunate youth is taken quite unaware. Suddenly he finds himself endowed with vocal cords of a length to which he is quite unaccustomed. The nerves and muscles that move the pieces of gristle have not yet come to realize what is expected of them under the new conditions, and for a while the youth is not quite certain, at any given moment, whether the sound he is about to bring forth from his larynx will be high or low pitched. Meantime the larynx continues its growth, and by the time it has become a prominent feature of his anatomy he has learned the trick of this new instrument and begins to speak with a deep and confident voice.

It is interesting to consider why this great and sudden increase in the growth of the larynx should affect one sex only. To find an answer to this question we must look back to the rude beginnings of human life, to the lawless wilderness where our half-human ancestors passed their lives. We must pictures to ourselves the fierce and ruthless encounters with aggressive enemies that were frequent experiences of the primitive lover and primitive father. In such encounters it would be he who possessed a deep, strong voice to express his jealousy and rage who would best succeed in driving off the intruder and protecting his offspring. Thus his offspring would live to perpetuate the deep voice, and by continued inheritance fix it as a male characteristic.

There is, perhaps, no change taking place in the body during its development more reminiscent of our racial history than the phenomenon of "teething"; but here one may give only the briefest sketch of this process. When a baby is born there are, of course, no teeth in the mouth; but they are lying beneath the gums, embedded in the jaw. Some six or seven months later they will begin to appear in the mouth. The first to appear are the central teeth of the lower jaw. A few months elapse before the central teeth of the upper jaw appear. Then there is a rest of a few months, and more teeth appear in the lower jaw, including the first molar teeth. This process of alternate eruption of teeth and resting goes on for eighteen months, so that a child of two has a complete set of milk teeth—ten above and ten below. This set of teeth serves the child for four years. At six or seven years of age a new tooth gradually makes its appearance behind the set of milk teeth. This new tooth is the first of the permanent set. The milk teeth now begin to drop out one by one as the months and years pass on, and when one sees a little boy or girl with a toothless space in the front of the mouth one may guess that the child is about six years old. The permanent teeth are constantly making their appearance in the mouth at intervals during the period between the sixth year and the twelfth year. By the thirteenth year the permanent set of teeth is practically complete; for among civilized races the wisdom teeth hardly serve as teeth, however useful they may be to the negro. The wisdom teeth may appear any time after the seventeenth year. Their advent may be postponed until the thirtieth or fortieth year, and sometimes they do not appear at all.

It must be clearly understood that I have been endeavoring to give merely an indication of the changes that take place in the body during its development. In the course of writing this article I have seen many opportunities for moralizing on physical and mental education; but, remembering the space at my disposal and the scope of the matter in hand, I have refrained from any such references. The purpose of my article is served if I have helped my readers to realize that a child becomes a man or a woman by metamorphosis as well as by increase of bulk.

PANAMA CANAL PROGRESS.

ACCORDING to the Canal Record, Ancon, Canal Zone, April 6th, if the original plan adopted by Congress had been adhered to, the excavation for the Panama Canal would have been completed by this time. That plan provided for a total excavation of 103,795,000 cubic yards. Changes in the plan made subsequently by order of the President, added 70,871,594 cubic yards, bringing the total to be excavated up to 174,666,594 cubic yards. The estimate of time required for the construction of the canal as originally planned was nine years.

The grand total of excavation accomplished down to the end of March, 1910, is 103,205,666 cubic yards, or within 589,334 cubic yards of the total required for the canal as originally planned. As the average daily output exceeds 100,000 cubic yards, the full excavation required by the original plan has since been accomplished.

Active excavation work on a large scale did not begin till 1907, and in that year 15,765,290 cubic yards were removed. In 1908, 37,116,735 cubic yards were removed, and in 1909, 35,096,166, making the total for the two years 72,212,901, a monthly average for the entire period of over 3,000,000 cubic yards. The total excavation of 1904, 1905, and 1906 was not quite 7,000,000 cubic yards, so that nearly the entire excavation called for under the original plan has been accomplished in three and a quarter years. The excavation remaining to be accomplished is the 70,871,594 cubic yards made necessary by the changes in the plan.

The grand total of canal excavation in March was 3,067,479 cubic yards, 476,750 cubic yards more than the total for February, although the rainfall in March was the heaviest since work was begun by the Americans, and at the principal points along the line of the canal exceeded the average for all the years of record. The dry excavation amounted to 2,178,618 cubic yards and was principally by steam shovels. The dredges removed 888,861 cubic yards in addition to the amount pumped into Gatun Dam by suction dredges.

The record excavation for a single steam shovel, working eight hours a day for a month, was made by shovel No. 213, which removed 70,290 cubic yards place measurement. The highest record for a single day was made by the same shovel, 4,823 cubic yards, place measurement, in a day of eight hours.—The Iron Age.

Owing to the climatic conditions in Richmond, Va., the wooden panels on the cars are frequently cracked. Instead of replacing them with new wood panels, the Virginia Railway and Power Company covers the old panels with steel of No. 18 gage. These steel sheets are screwed on under the old side moldings and when painted they cannot be distinguished from wood. In fact, there are many cars which have wood panels on one side and steel-covered panels on the other. When steel panels are applied they are continued past the belt rail without a break, and this prevents the rotting which occurs when water from the belt rail gets inside the car between the joints of the wooden half-panels. The plates are shaped in the company's shops, and are applied whenever it is found that a considerable number of the wooden panels are split.

MEASURING INSTRUMENTS OF LONG AGO.*

THE MECHANICAL APPLICATION OF GEOMETRICAL PRINCIPLES.

BY WILLIAM E. STARK.

A FEW years since, in searching for practical problems to vitalize high-school work in algebra and geometry, I looked through many artisans' manuals. In the course of this search, I found in a carpenters' handbook of fifty or sixty years ago descriptions of several obsolete instruments, which furnished excellent illustrations of simple geometric principles. Having struck "pay ore," after much profitless digging, I determined to follow the vein. The task has been altogether delightful and has yielded not a little material which will add life to the stereotyped five books of geometry. The facts and illustrations given below are taken from the collection of books and instruments belonging to Prof. David Eugene Smith of Columbia University. Most of the books referred to are of the sixteenth and seventeenth centuries.

The chief advantage of these old instruments for educational purposes lies in their simplicity. Modern science demands such a high degree of precision that most measuring instruments of to-day are too complex to be easily understood by the young student. The devices for increasing the accuracy or extending the field of use of one of these modern instruments obscure its fundamental principle. The engineer's transit is many instruments in one.

The primitive instruments were intended for a single purpose and were based on a single principle. To be sure, there are in the books referred to many examples of the tendency to combine instruments, and many an author undertakes to show how his invention may be used to do the work of all others. Nevertheless, the simplest devices will be readily grasped by the youngest high-school pupils, and all that I refer to will be understood by the older students.

The chief value of this material is, I think, for giving concrete illustrations to the abstract theorems. Even the impractical devices will be of service in stimulating the student to follow the inventor's

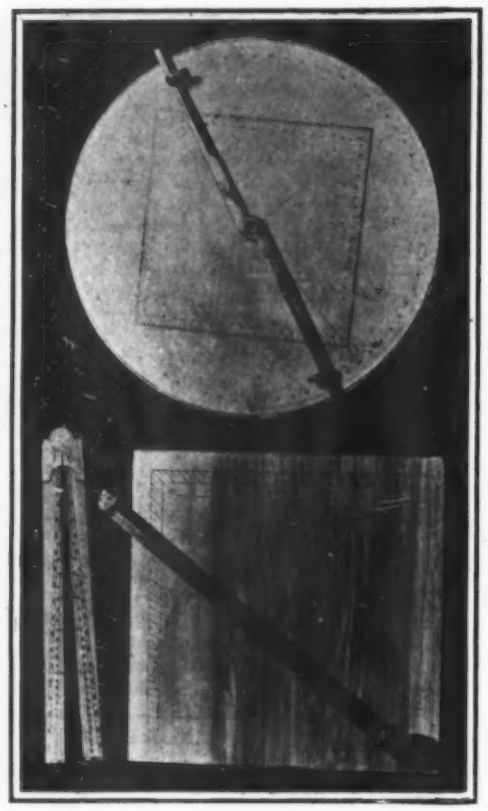


FIG. I. REPRODUCTION OF OLD MATHEMATICAL INSTRUMENTS MADE BY PUPILS.

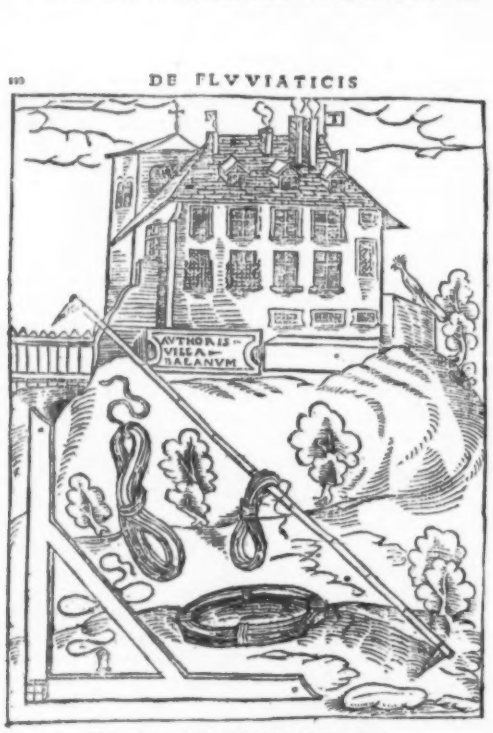


FIG. II.—SURVEYORS' TOOLS.
From Opera Geometrica by J. Buteo, Lyons, 1554.

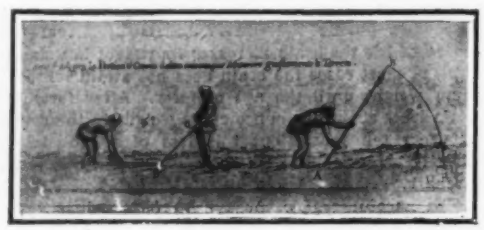


FIG. III.—USE OF RODS IN LINEAR MEASUREMENT.
From La Geometria Prattica by G. Pomodoro, Rome, 1624.

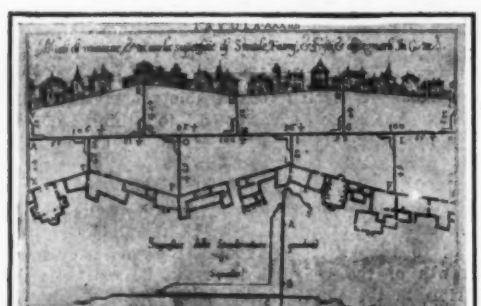


FIG. IV.—USE OF SIMPLE SQUARE IN SURVEYING A STREET.
From Pomodoro. (See Fig. III.)

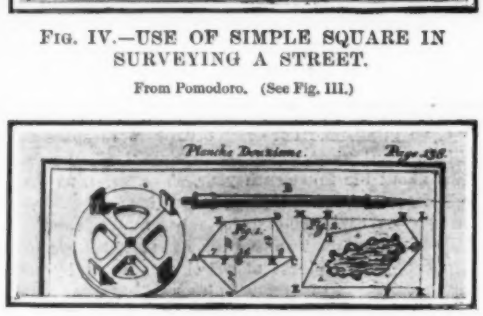


FIG. V.—SURVEYOR'S CROSS.
From Bion, Traité de la Construction et des Princ'paux Usages des Instruments de Mathematique. The Hague, 1723.

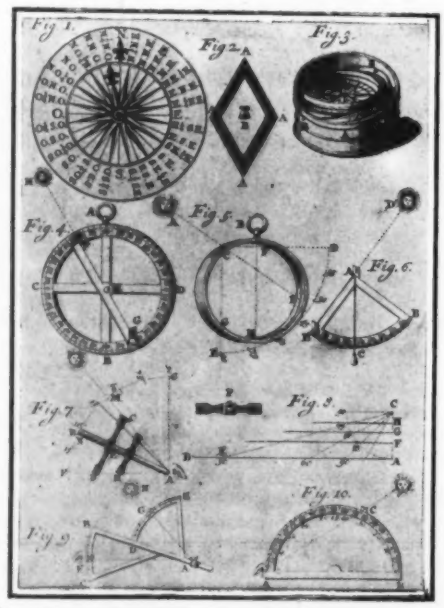


FIG. VI.—NAVIGATION INSTRUMENTS.
From Bion. See note under Fig. V.

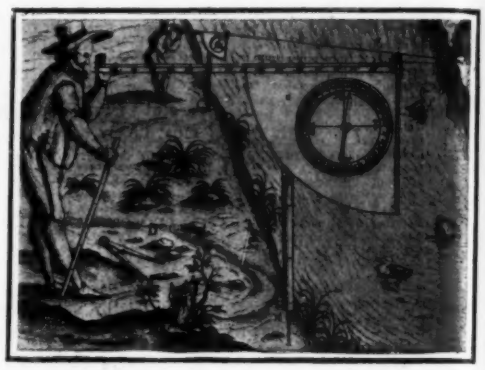


FIG. VII.—EARLY FORM OF SURVEYOR'S COMPASS.
From De Quadrante Geometrico by Cornelius de Judaeis, Nuremberg, 1594.

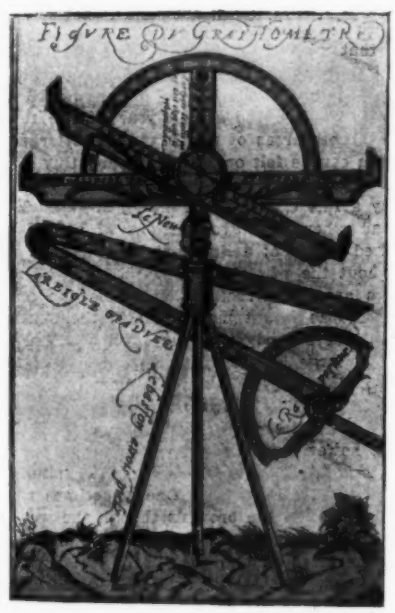


FIG. VIII.—INSTRUMENT FOR MEASURING ANGLES.
From Declaration de l'Usage du Graphometre by Philippe Danfric, Paris, 1597.

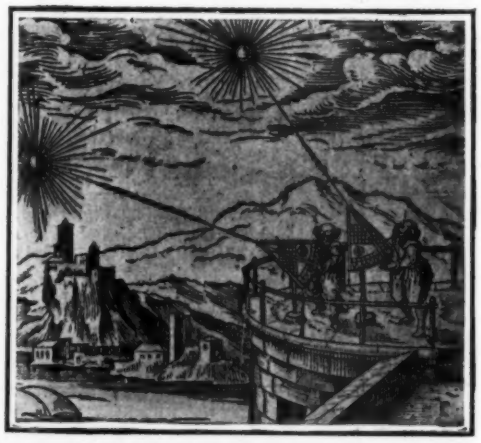


FIG. IX.—OCTANT FOR MEASURING ANGLES AND ESTIMATING DISTANCES BY PROPORTION.
From De Octantis by H. Hofmann, Jena, 1612.

* School Science and Mathematics.

thought and to discover the sources of error in his process. When an author proposes to determine the distance to a point more than a thousand feet away, using a base line five feet long, our student of geometry is likely to take some satisfaction in proving the inaccuracy of the method.

Some of the instruments may well be used for field problems and simple surveying. A good transit is beyond the reach of most schools, but many of the instruments described below can be constructed easily and cheaply by a boy who has had some training in woodworking. A few illustrations of instruments made by boys of the Ethical Culture School are shown.

FIG. X.—DEVICE FOR LAYING OUT PLOTS.

These instruments form a nucleus for a little mathematical museum, and are used occasionally for field practice. If it be suggested that the results obtained by such crude instruments will be too inaccurate to interest pupils in making the measurements, it should be remembered that surveyors and military engineers found these same devices accurate enough for all their work for some centuries. One who has used only precise instruments will be surprised at the degree of accuracy which it is possible to obtain after practice with such simple tools as those described.

INSTRUMENTS FOR MEASURING DISTANCES.

The instruments used for making direct measurements of length in the sixteenth and seventeenth centuries were rods of various lengths, subdivided into smaller units, cords with knots to mark the divisions, and chains much like those still in use. The most noteworthy characteristic of these linear measures is the variability of the units. After reading a few pages of "equivalents" for use in turning units of land measure of one city into those in use in adjacent places, we wonder first why there should be complaint of present conditions, and then why, when such notable progress has been made, it should be so difficult to take the last step.

Ottavio Fabri* in his treatise on the "squadra mobile" gives tables of linear and square measure for twenty-one cities, nearly all of them in Italy. He says: "In Ferrara, land is measured by the *mozo*, which is 66 poles (pertiche), 6 feet and 8 inches long and 20 poles wide. In the measures of Ferrara these 66 poles, 6 feet and 8 inches are equivalent to 116 poles, 4 feet, 8½ inches in the measures of Rovigo, and the 20 poles of the width are equivalent to 35 poles and 2½ inches. The product of these is 4,091 *tavole*, 3 feet, 2 inches, which is equivalent to 4 *campi*, 3 quarters, 101 tavole, 3 1/6 feet in the measures of Rovigo. The 66 poles, 6 feet and 8 inches in Ferrarese measures make 127 poles and 2 inches in Paduan units, and the 20 poles of the width make 38 poles, 8 inches Paduan. The product is 4,841 1/6 tavole, which is equivalent to 5 *campi*, 3 quarters, 11 1/6 *tavole*."

INSTRUMENTS FOR MEASURING ANGLES.

For laying off right angles, a tool like an ordinary carpenter's square was often used. Fig. IV shows such a square attached to the measuring cord for use in laying out perpendicular offsets. Another device for the same purpose was a sort of cross mounted on a staff (see Fig. V).

For measuring angles a graduated circle or circular arc was employed. In some instruments the angle

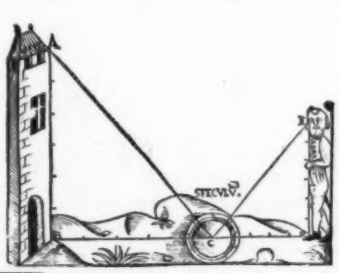


FIG. XI.—USE OF MIRROR IN MEASURING A HEIGHT.

From De Re et Praxi Geometrica by Orontius Finaeus, Paris, 1556.

was read by means of a rule or alidade, pivoted at the center of the arc; in others a plumb line hanging across the scale indicated the angle, while in still others the reading was taken at the point of a magnetic needle. An example of each of these types is given in the following illustrations.

In Fig. VI, 4, a simple form of astrolabe, a full circle graduated in degrees, carries an alidade with sights through which the observation is made. For measuring the altitude of the sun, the astrolabe was supported by the ring at the top, the plane of the instrument turned toward the sun, and the alidade revolved until a beam of light passed through both sights. The edge of the alidade touching the scale then indicated the required angle. This instrument mounted on a staff could also be used in a horizontal plane.

In Fig. VI, 6, is shown a quadrant with graduated arc and plumb line hung from the center. In the illustration an angular altitude is being measured by aiming one of the bounding radii at the sun. The plumb line indicates the angle. The principle here exemplified is met by the student of geometry within a few days after the beginning of the course.

Fig. VII is an engraving of an instrument using a magnetic compass for measuring angles. The angle which any line makes with the magnetic meridian is obtained by setting the line of sight—which is parallel to the zero diameter of the compass dial—in coincidence with the required line, and noting the point on the dial indicated by one end of the needle. Of course any angle can be calculated when the bearings (angles with the meridian) of its sides are known. This instrument does not differ in principle from the surveyor's compass still in use.

In many instruments a semi-circular arc was used for measuring angles (Fig. VIII), and an author writing in 1612 dilates on the advantage of an octant (Fig. IX). In the latter instrument the principle of

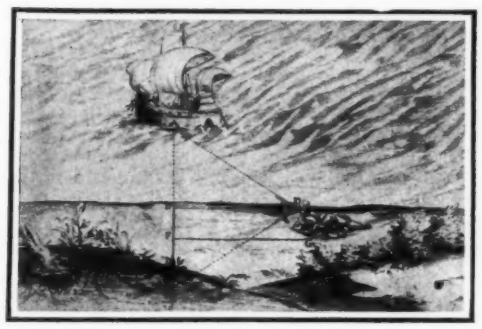


FIG. XIII.

From Apiaria Universae Philosophiae Mathematicae, by M. Bettinus, Bologna, 1645.

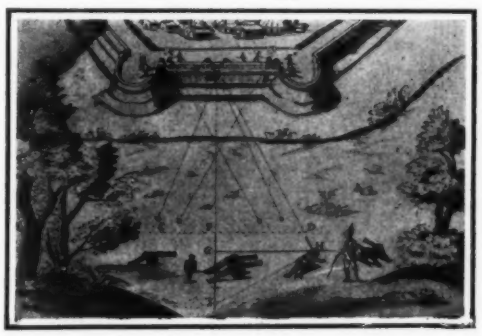


FIG. XV.—MEASURING DISTANCES FROM A FORTRESS.

From Bettinus.

the diagonal scale was used to subdivide the arc into ten-minute intervals.

A few inventors made use of the principle of measurement of inscribed angles. In the ring (Fig. VI, 5), used in navigation for taking the altitude of the sun, a ray of light passed through a small hole, *C*, and fell on the inner surface of the ring opposite the hole. The scale on this inner surface was formed by dividing the semi-circumference of the ring into ninety parts, the zero being at the same level as the hole which admitted the ray of light. Thus the tiny spot of light falling on the scale indicated the altitude.

An interesting device for increasing the accuracy of an instrument without adding greatly to its weight is shown in the English quadrant (Fig. VI, 9). This consists of a staff, *AB*, about two feet long, to which are attached two arcs, *BC* and *DE*, as shown in the diagram. *DE* is divided into sixty divisions of one degree each. *BC*, which subtends an angle of thirty degrees, can, on account of its longer radius, be divided into spaces of five minutes each. Each arc carries a movable sight (*F*, *G*), and a third sight is placed at *A*, the center of both arcs. In practice, *G* is placed at any convenient division, and *F* is moved until the angle *GAF* coincides with the required angle, and the sum of the readings on the two arcs is taken. In measuring the altitude of the sun, *F* is held at the eye, *A* is aimed at the horizon, and *C* is raised or lowered until a ray of light passing through *G* falls at *A*.

Mutio Oddi,* writing at Milan in 1625, describes an instrument in which fixed sights are placed at convenient angles with each other, as shown in diagram in Fig. X. The diameter *OR* bisects the quadrants *CMA* and *SM* ✣, while *IN* makes an angle of thirty degrees with *C* ✣. This device was to be used in laying out plots of land in the shape of regular polygons.

FIG. XII.—MEASURING WIDTH OF STREAM.

From "Del Misurar con la Vista" by Silvio Belli, Venice, 1569.

The instrument was set either at the center or at a vertex of the proposed polygon, where by selecting the proper sights, the observer could lay out the required angle for many of the polygons. When an angle could not be obtained directly from the instrument, the nearest angle was laid out and corrected by means of

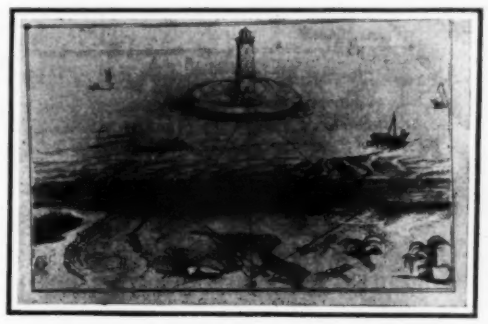


FIG. XIV.

From Bettinus. See note under Fig. XIII.

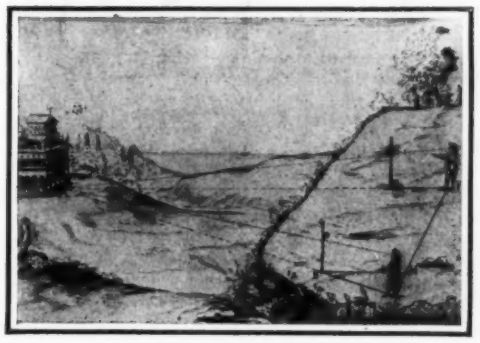


FIG. XVI.—FINDING DISTANCES ACROSS A VALLEY.

From Bettinus.

a table of tangents given by the author. On reaching the theorem on the sum of the angles of a polygon, pupils will be interested in seeing how many of the regular polygons can be constructed by using angles taken from a figure like the one referred to.

The *radius astronomicus** used by astronomers for taking angular distances consisted of a staff with a cross-bar which could be moved along the staff, always remaining at right angles to it. The staff and cross-

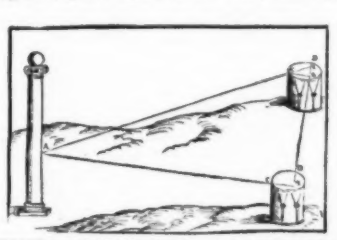


FIG. XVII.—MEASURING A DISTANCE BY PROPORTION.

From Belli. See note under Fig. XII.

bar were graduated in small divisions, and sights were placed on the cross-bar and at the end of the staff. For taking the angular distance between two stars, one end of the staff was held at the eye, and the cross-bar was moved until the sights, placed at equal dis-

* L'uso della Squadra Mobile. Ottavio Fabri, Venice, 1598.

* Dello Squadro, Trattato di Mutio Oddi da Urbino. Milan, 1625.

* Scripta Clarissimi Mathematici M. Johannis Regiomontani de Torqueto, Astrolabio Armillari, Regula magna Ptolemaica, Baculoque Astronomico, et Observationibus Cometarum Aucta necessariis Johannis Schoneri Carolostadii additionibus. Nuremberg, 1544.

tances on either side of the staff, were in line with the stars. Having read the number of divisions on the staff from the eye to the cross-bar and the number of divisions between the two sights on the cross-bar itself, the observer could look up the required angle in a table. The radius was provided with cross-bars of various lengths, the observer selecting the one best adapted to the size of the angle to be measured.

A later form of this instrument, used in navigation, had on each face of the staff a scale corresponding to one of the cross-bars, from which the angle could be read directly (Fig. VI, 7).

INSTRUMENTS FOR MEASURING DISTANCES BY PROPORTION.

The properties of similar figures are exemplified in many ingenious instruments and an indefinite number of problems. I shall mention first a few of the common problems solved without the aid of special instruments and then describe the devices invented for making similar measurements with greater accuracy.

Heights of towers and walls, widths of streams and moats and distances to inaccessible objects seem to have occupied much of the attention of practical mathematicians. Many of the authors refer to the ancient problems of calculating the height of a tower from the length of its shadow or from measurements to a mirror, placed on the ground, in which one sees the top of the tower (Fig. XI).

A quick but not very accurate method of measuring the width of a stream, was to plant a staff vertically on one bank, fasten near its top a shorter rod in such a position that it pointed at the opposite bank, then rotate the staff until the shorter rod pointed at a spot on the same bank as the staff. The required distance was then obtained by measuring from this spot to the foot of the staff. In Belli's geometry, 1569, this problem is illustrated by an engraving in which the observer himself takes the place of the staff and the visor of his cap the sighting rod (Fig. XII). This problem will serve as an illustration of the equality of two triangles, having two angles and a side of one respectively equal to the corresponding parts of the other. Pupils will be interested in finding out, by a drawing, how much error will result, if the staff is not quite perpendicular, or if the two points sighted at are not quite at the same level.

Much ingenuity is shown in devising figures in which the inaccessible distance is equal or bears an easily determined ratio to a line which can be measured directly. In the problem shown in Fig. XIII, the distance of a ship off shore is measured by bisecting the angle formed at the observer's eye by his line of sight to point *A* on the vessel and to a point *C* on the shore opposite *A*. The distance from *C* to the intersection of the bisector with *AC* is of course equal to the required distance.

In Fig. XIV, *EC* is the required line. *EB* is laid off perpendicular to *EC* and at any convenient point, as *B*, the angle *EBC* is measured. *CE* is then extended making *ED* equal to *EB* and angle *EDA* is laid off equal to *EBC*. The distance from *E* to the point of intersection of *DA* with *BE* produced is equal to the distance sought.

Fig. XV illustrates the measurement of the distance to a fortress from a point beyond the range of the cannon of the garrison. *EHI* and *HGI* being right angles, the measurement of *GH* and *GI* is sufficient for the calculation of the result.

Fig. XVI shows a method of finding the distance across a valley by measuring a base line, *CF*, and calculating the ratio of the sides of a small triangle similar to the large one of which the required distance is a side. Some solve such problems by sighting at the inaccessible object from two ends of a measured base line, representing the base line and the directions of the sights by lines on paper, and scaling the required distance. Belli shows how this may be done when needed in military operations, by drawing on a drum head (Fig. XVII).

(To be continued.)

"ILO," A THIRD UNIVERSAL LANGUAGE.

AN IMPROVEMENT ON ESPERANTO.

EVERY person who reads or writes scientific works has no doubt felt the want of a universal scientific language and deplored the loss of time and labor occasioned by the fact that literature, and particularly the literature of the exact sciences, is published in many languages.

We had once a common scientific language, Latin, but its decline could not be stopped. We all know the reason for this change. The development of natural history, introducing ideas which could not be expressed adequately in Cicero's tongue, the spread of knowledge among large classes of people having no classical education, the founding of polytechnic colleges, and finally the jealousy of nations which caused their scientists to write in their own languages—all this has worked together to drive out Latin in favor of modern languages.

Thus instead of a single scientific language we now have three: English, German, and French. But even the knowledge of these three is no longer sufficient: Italians, the Dutch, Russians, Poles, Czechs, Hungarians, Scandinavians, and Spaniards will frequently use their native tongues in their scientific works; many articles thus escape general notice or reach the public only with considerable delay or in mutilated form.

Conditions are still worse in oral intercourse, especially at scientific congresses. Every member of a congress will have noticed that whenever a speaker addresses the meeting in a different language, a considerable portion of the audience will leave more or less noisily, not wishing to be present at the reading of a paper they cannot understand.

A writer in Umschau therefore finds a real demand for a general scientific language. Any attempt to adopt one of the modern languages for this purpose would be hopeless since international jealousy alone would wreck it. The widely-used English language, which might be favored on account of its simple grammar, would be little suitable in view of its extremely difficult pronunciation. Universal acceptance, therefore, can be expected only in the case of a language built up on possessions common to all those nations for whom the general language is intended. Here the objection will be made: "So you mean an artificial language, that is, a Utopian plan! How can anybody think of artificially producing a language, which is a kind of organism capable of spontaneous development and continued life! You might just as well propose to artificially create a living horse." It is true we cannot make a living horse, but we can make an automobile capable of taking the horse's place under certain conditions, and even surpassing it in efficiency. Just as the automobile did not become of practical importance until countless experiments had been made, so the idea of an artificial international auxiliary language, which to-day can look back upon an evolution lasting three centuries, did not, at first, yield any practical results.

The first universal language to find actual use was Schleyer's "Volapük." This linguistic experiment carried out with admirable thoroughness, is indeed very instructive and important, and very interesting are the conclusions as to theory and practice of the international language which may be drawn from the growth and the early decline of the Volapük movement. Yet this decline showed very clearly that in such things also experience is the only true teacher. The fate of Volapük was sealed when its adherents in 1889 ventured the experiment of calling a congress at which Volapük was to be spoken. Although a few Volapükists actually succeeded in speaking this language, the attempt showed with cruel clearness that the goal could not be reached with this system.

Almost simultaneously with the invention of Volapük, the Russian physician Dr. Zamenhof published his system under the pseudonym of "Doktoro Esperanto." But as Esperanto appeared just while Volapük was at high tide, it did not create any impression at first. In France it found a zealous champion in the Marquis de Beaufront, to whom the Esperanto movement owes its greatness.

Zamenhof's contribution is to be highly esteemed, since at a time when the question of the best construction of an international language had not even been seriously raised, he succeeded in building up one that in many respects surpassed the attempts made previously and in practical use proved a suitable means for international intercourse. Still, Esperanto needed improvement in various directions: The Esperanto characters are partly distinguished by a circumflex, which is a drawback in writing and printing. Besides the ordinary parts of speech, which have their characteristic terminations or suffixes, Zamenhof employs a new one invented by him; the limits of this class of words, which comprises some adverbs and prepositions, but not all of them, are not clear by any means. Many words taken from well-known languages are mutilated. The paucity of roots is so great as to lead to word formations the meaning of which cannot be guessed readily.

The Esperanto language thus cannot as yet be considered the solution of the problem. The intelligent leaders of the movement are fully aware of this, particularly M. de Beaufront as a champion of the reform, which the inventor Dr. Zamenhof himself has approved in very material points. The proposed improvements are, however, rejected by the so-called fundamentist party, in league with a few large publishing houses who are defending their business interests. These companies have a monopoly of the rather important trade in Esperanto publications, by reason of the fact that Esperanto contains no less than six characters specially invented for it, which are not found in any ordinary printing establishment. They have therefore, as it were, declared holy and infallible the grammar published by Zamenhof under the name of "Fundamento de Esperanto" and the reader and the dictionary issued in connection therewith, and even go so far as to venerate as "correct" and "classical" Esperanto the infractions of Dr. Zamenhof's own rules, some rather bad errors of grammar, and even the misprints found in said books.

Under the circumstances no progress can be expected from Esperanto, and it is therefore encouraging to hear that a plan has just been published for the creation of a world language based on Esperanto but avoiding its defects. This plan is the result of many years' work by an association of the most competent linguistic scholars, the "Delégation pour l'adoption d'une langue auxiliaire internationale," formed in connection with the International Exposition held in Paris 1900.

The international character of the language proposed by the delegation is shown best by the following statistics, compiled by Couturat. He counted the roots employed in the first dictionary of the new language (a total of 5,379) and found the following numbers among the words of present-day languages:

French, 4,880; that is, 91 per cent
Italian, 4,454; that is, 83 per cent
Spanish, 4,237; that is, 79 per cent
English, 4,319; that is, 79 per cent
German, 3,302; that is, 61 per cent
Russian, 2,821; that is, 52 per cent

The grammar of the new language complies absolutely with the chief requirement of an international language system: perfect regularity. In this new language there are rules which may be printed on one page easily, and no exceptions. If you know the conjugation of one verb, you know that of all others, and so on.

The result is a language which may be mastered readily by anybody and which has this advantage over other artificial languages, that it is based on rational scientific technical principles and therefore is not exposed to the danger of being supplanted by the creation of a still better and materially different language. Of course details may be improved here and there, but the foundation seems secure, and the common auxiliary language of men cannot assume an appearance differing very much from the newly-created Internaciona linguo, or by its contracted name, Interlingo, or still shorter, using chiefly the initials, Ilo.

Whoever wishes to learn more about the nature of Ilo, will find information in the interesting pamphlet "World-Language and Science," published at Jena, 1909, by Gustav Fischer, and written by five well-known professors and committee members of the delegation, L. Couturat of Paris, O. Jespersen of Copenhagen, R. Lorenz of Zurich, W. Ostwald of Gross-Bothen, and L. Pfaundler of Graz.

A specimen will show better than long explanations that the new world-language is not an unpronounceable, artificial production, but a euphonious language which lends itself to easy and fluent treatment:

Literal English translation from the German original of a passage from Gompers, Griechische Denker, 2nd volume, 2nd edition, page 36; Leipsic, 1903.	L. Couturat's translation from the German original into Linguo Internaciona di la Delegitaro (Ilo).
Socrates' Life and Activity.	Vivo ed Agado di Sokrates.
Clear, cool heads of considerable strength have existed in all centuries, and also of warm hearts there did not often reign a sensible want. But a warm heart beneath a cool head, that is a rare combination, and the rarest of all phenomena is a heart working with unusual might, which uses its whole impulsive power to keep the head cool—comparable to a steam boiler which operates an ice-plant. Scarcely once in thousands of years will such a combination on a grand scale recur.	Klara, malvarma kapi di suficanta forteso existis en omna yarcenti, ed anke de varma kordyi ne ofte regnis sentebla manko. Sed varma kordyo sub malvarma kapo, to esas rara uniono, e la max rara de omni fenomeni esas kordyo laboranta per extraordinara forteso, qua uzas sa tuta impulsovo a konservar malvarma la kapo—komparebla a vapor—kaldrono, qua funcionigas glacyofabrikelo. Apene un foyo en yarmili revenas tala uniono en granda mezuro.

THE PROPHECY OF FRANCIS BACON, 1560-1910.*

A PIONEER IN NEW FIELDS OF INTELLECTUAL ENTERPRISE.

BY PROF. RALPH BARTON PERRY, HARVARD UNIVERSITY.

I. *Bacon and the Spirit of Discovery.*—There are several ways in which the importance of a philosopher may be estimated. He may be regarded as an exponent of his times; that is, as a representation in which the manifold tendencies of an age are focalized and idealized. Or he may be regarded as the author of a panorama of existence, of a world-view or system, which, while it may be superseded, will always retain enough of logical and imaginative coherence to make it typical and classic. Or the philosopher, like other servants of mankind, may be judged according to the degree in which he has been confirmed by posterity. Judged by this last standard, the great philosopher will be the philosopher who, while he may, like Bacon, have been born three hundred and fifty years ago, is nevertheless modern, in the sense that he is identified with important ideas which are now generally held to be true. This brief summary aims to present the Bacon that is living to-day in our common opinion, in our expert knowledge, and in our dominant ideals.

Any one who considers Bacon in relation to European civilization of the modern period must be impressed with the degree to which he represents its progressive ideas. Those characteristics of the sixteenth and seventeenth centuries which are most marked in Bacon are the characteristics in which they anticipate later centuries. It is possible for our immediate purposes to reduce these characteristics to one: The disposition, namely, to look for a betterment of human life from the advancement of knowledge. "Advancement of knowledge" does not here mean the education of the individual, but the winning of new truths by the race and for the good of the race. We may call this the spirit of discovery, where "discovery" is used both in the theoretical and in the practical sense. Bacon himself was not a discoverer of new scientific truths, but the discoverer of the art of discovery. As he expressed it, he "rang the bell that called the other wits together." While it is doubtless inaccurate to attribute so general an idea to any individual authorship, Bacon was its greatest prophet. His brilliant literary gifts, his imagination, his sanguine temperament, his breadth of view and his native regard for utility, the very qualities that helped to unfit him for exact research, made him the most important medium through which the idea of discovery, or of intellectual conquest, has gradually become the hope of mankind.

II. *The Baconian Reform.*—This idea was defined by Bacon largely in opposition to what he believed to be the blindness and errors of his own and earlier times. Philosophical literature nowhere else contains so acute and so comprehensive an examination of man's intellectual bad habits. Bacon's criticisms may conveniently be brought together under four heads.

First, he defined the persistent error of *anthropomorphism*. It is customary for man to fashion things after himself. He is deceived by what Bacon calls the "idols of the tribe" or the prejudices characteristic of human nature in general, and by the "idols of the den" or the prejudices peculiar to the individual. But if he is to view nature as it is, he must efface himself.

Second, he found the thought of his own time to suffer peculiarly from *conventionality*. It was customary for men to accept what was current and supported by general opinion: There are two important means through which arbitrary or ungrounded ideas are foisted upon belief: language, which gives rise to what Bacon calls the "idols of the market-place," and established systems, or theories which have the stage, and which give rise to what Bacon calls the "idols of the theatre." In the interests of truth it is necessary to guard against the suggestive power of words, which are often obscure or even meaningless, and against the inertia of doctrines that have acquired repute and prestige.

Third, it was customary in Bacon's time, to a degree that is scarcely intelligible to-day, to assent to theories of nature on grounds of *authority*, ecclesiastical or political. Bacon is among the first to formulate the principle of tolerance, according to which there is hope of knowledge, provided only that the mind be free from external constraint. The truth-seeking mind can acknowledge no obligations except to evidence.

Fourth, Bacon attacked the tendency, common at the time of the Renaissance, to rely on *antiquity*. The essentially modern character of Bacon's mind is nowhere more apparent than in his repudiation of the idea that dominated the revival of letters. He detected the dangerous fallacy which had arisen with the new study of the ancient languages and literatures. Historical retrospect inverts the intellectual values of the race. The wisdom of the ancients is but the folly of youth—*Antiquitas saeculi juventus mundi*. The hope of knowledge lies not in a return to childhood, but in a maturity yet to come.

III. *The Baconian Survey.*—As a pioneer in a new intellectual enterprise, it fell to Bacon to draw a rude map of the settled domain and border wilderness of knowledge. It is impossible here to enter into the merits and demerits of his classification of the sciences. Most interesting to us of the present is his explicit provision for what is now known as "applied science." But there can be no doubt of the service which Bacon rendered in making such a classification at all. To Bacon modern science is largely indebted for the sense of solidarity that obtains among all special investigators. He was, in a measure at least, responsible for the organization of the Royal Society in London, and of similar societies on the Continent. He inspired the collective scientific movement of the Encyclopædists; and, directly or indirectly, the systematization of science made by Comte, Spencer and others. The present idea, then, that the several sciences are the members of one body, and that those who serve them are serving in one army to achieve the conquest of the unknown, is an idea to which Bacon testified clearly and effectually.

IV. *The Baconian Method.*—But Bacon did not merely point out the promised land and exhort men to discovery; he organized a plan of campaign. There is an opinion to the effect that while Bacon was enlightened in his general ideas, he was benighted in his particular ideas. This opinion is entirely unjust. Bacon does make many of the mistakes current in his time; and he deliberately makes many loose statements in hope that they may prove suggestive and stimulating. Furthermore, he necessarily uses terms, such as "form," which, because they were borrowed from Greek and medieval thought, suggest to our minds something pre-scientific and obsolete. But this very term, as actually employed by Bacon, is the closest approximation in his time to the modern conception of cause, as employed in such sciences as molecular physics and chemistry. Furthermore, and be it said to his great and enduring credit, he was the great systematizer and popularizer of experimental method. The incompleteness of the Baconian method is the incompleteness of the experimental method. Although he did not by any means ignore it, it is true that Bacon did not adequately realize the importance of the quantitative or mathematical formulation of scientific laws. But this fact in no wise affects the correctness of his statement of the experimental method. The Baconian plan of research, avoiding technicalities, may be said to contain four important ideas, all of which have been approved and employed in subsequent scientific procedure.

His first and fundamental idea is that of *observation*. Bacon never wearies of reminding us that the mind must be brought into direct contact with things. In the study of nature, we may see, he believes, by the "ray direct." To avoid verbalism, dogmatism or ambiguity, it is necessary that the mind should be open to the facts, and that it should follow their leading. "We can only conquer nature by first obeying her." But Bacon understood the fruitlessness of desultory observation. For purposes of explanation all facts are not equally significant.

Hence, secondly, he was led to define certain methods or *canons of induction*. It was Bacon who first called attention to the importance of "glaring" or "striking" instances, in which the phenomenon under investigation is thrown into relief; "parallel" instances, which permit of the argument from analogy; and "crucial" instances, which serve as tests of contrary hypotheses. From Bacon, Mill derived the methods to which he gave such prominence in his *Logic*, the methods, namely, of "agreement," "difference" and "concomitant variation." By means of these methods it is possible to single out from among the circumstances attending or preceding the phenomenon to be explained, that which is its probable cause. That which is present when the phenomenon is present, which is absent when the phenomenon is absent, and which shows like quantitative changes, may be assumed to be connected with the phenomenon, and to point the way to its explanation.

But, thirdly, it is necessary to supplement observation of the natural course of events with artificial *experiments*. Nature, like men, will reveal her secrets only when put to the torture. Bacon was a consistent advocate of the first-hand manipulation of natural bodies. He saw this to be the only method of study which afforded any prospect of laying bare the more "subtle" physical phenomena, such as heat, light, and the transmutation of substances. The later development of physics and chemistry not only confirmed this judgment, but in several signal cases fulfilled definite predictions which Bacon based on it.

Fourthly, Bacon recommended the *comparative* and *historical* method. He was one of the first to appreciate the importance of studying all phenomena that develop, in different stages of their development. In the particular case of anatomy, he called attention to the importance of studying the structure of organs in their simpler forms, and using the results as a key to the complex forms.

V. *The Baconian Pragmatism.*—Bacon's extraordinary modernism appears not only in his definition of sound and fruitful methods of scientific study, but also in his conception of the relation of science to civilization. And in nothing is he so modern as in this. He asserted that the hope of man lay in his advancing knowledge and control of nature. This idea is undoubtedly a present commonplace, but there are few philosophers that anticipate the commonplaces of mankind by three centuries and a half! But the idea is too fundamental properly to be called a commonplace. It is the most fruitful idea in modern life, the main presupposition of progress. Bacon sought to promote learning for the sake of power. That this is essentially a modern idea will be apparent to any one who will study the motives underlying earlier periods of European civilization. The ancient world had its critical and its dogmatic idea of progress. The former was that of national or racial aggrandizement, the conquest of territory and political control. The latter, contributed by the genius of Greece, was the humanistic idea of the intensive cultivation and refinement of human nature. These ancient ideas were susperseded by Christian supernaturalism, which referred man's hope of salvation to another world which might be won by the repudiation of this. As Christian Europe became secularized there developed the theocratic idea of a fixed system in which all human activities should be limited and controlled by religious authority. Finally, as a reaction against the established order, there appeared the idea of the Renaissance, an enthusiasm for antiquity, and desire to reverse the course of history. The modern idea, though it borrows something from all of these ideas, is fundamentally different. It bespeaks a solidarity of mankind in the enterprise of life, and in this manifests its christianity; and it derives from paganism a respect for human capacities, and a confidence in man's power to win the good for himself. But these motives are so united in the modern spirit as to produce something genuinely new. The good is to be won by the race and for the race; it lies in the future, and can result only from prolonged and collective endeavor; and the power to achieve it lies in the progressive knowledge and control of nature. This is the Baconian idea. The incentive to knowledge lies in its application to life. "For fruits and inventions are, as it were, sponsors and sureties for the truth of philosophies." Therefore, Bacon would have men of learning begin and end their study with the facts of their present environment. "For our road does not lie on a level, but ascends and descends, first ascending to axioms, then descending to works." In the last part of the New Atlantis there is a remarkable description of the riches of Solomon's House, the great museum and laboratory, the treasure house and workshop, which was "the lantern of this kingdom." The words with which the father of Solomon's House receives his visitors are a terse and eloquent summary of that which Francis Bacon prophesied, and which posterity has steadily achieved. "The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible."

* Popular Science Monthly.

India rubber under tensile stress contracts strongly when its temperature is raised. Work is done by its contraction at the expense of the energy of the heat. Hence, according to Prof. S. P. Thompson, it would be possible to construct a thermal engine in which the working substance is India rubber, instead of steam or hot air, and operating by contraction, instead of expansion, of the working substance.

A PROFILE PUPPET-SHOW.*

HOW IT CAN BE MADE AND USED.

BY A. ROZE.

THE making of the figures, etc., in a profile marionette show differs considerably from the regular marionette puppet-show, the latter consisting of well-constructed dolls, carefully made and full of mechanism, dressed in silk and satin costumes, all of which occupy a long and arduous time in the making. Here the author has worked out a marionette show which should cost but little money, and much time need not be spent in its completion. When finished, it will not only be an entertainment for the drawing-room, but is equally suitable for the garden, under the shadow of some leafy tree, and, when well manipulated (a pretty easy matter with profile figures), a most enjoyable and mirth-provoking show. When in the garden, place the stand so that the sun does not shine on the proscenium-front and platform.

The drawings illustrating this article are made so clear that the young mechanic and showman will find no difficulty in proceeding with his work without hesitation. The figures must be made of cardboard, colored and tinseled, the construction of which will be given later on. First we will make the show, or fit-up. Fig. 1 shows the proscenium-front, with the curtain up, and ready for the performance to commence. The curtained front here seen should be made all in one piece, suspended from the top by a bamboo pole. The reason for its being in one piece is portability in setting up and packing away. The opening showing the scene may be of any measurement desired, according to the size and proportions of the figures; but a 2 foot 6 inch opening will be found in most cases sufficiently large, and the height in center, where the ball fringe is seen, 1 foot 8 inches; the curtain on either side about 18 inches in width. The depth of curtain from the platform to floor must be determined by the height of the chairs upon which the structure rests; the same applies to the curtain above the proscenium opening. The depth must be calculated by the height of the marionette manipulator, who must be completely shielded when standing on a chair or a box, working the figures over the top of scenery.

preference, should be made of some dark material—an inexpensive stuff such as can be purchased at most linendrapers' shops—say a cheap cretonne. The curtain must be made with a hem along the top to admit of a small bamboo rod being passed through *A* (see Fig. 2).

The fit-up must now be constructed. The platform

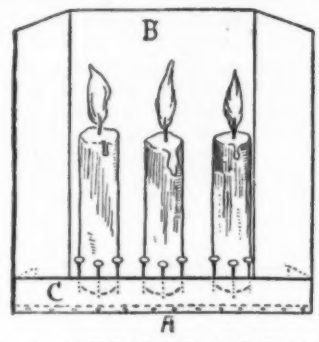


FIG. 3.—METHOD OF ARTIFICIAL ILLUMINATION.

is a single plank of deal, ½ inch thick, 9 inches in width, and 4 feet in length. The proscenium opening being 2 feet 6 inches, it will be found that about 9 inches extend at either end, as shown at *B*. This is useful to stand the candles on which are to illuminate the stage, also to fix the uprights *C* on that support the drapery, the curtain *D*, and also the scene *E*. The uprights *C* will be found strong enough if made from deal battens 1½ inches square.

Four uprights, or posts, are required—two for the front and two for supporting the scene *E*. The height of the posts for curtains must be determined by the height of curtain, as already suggested. The posts are kept in their places by screwing on to each piece an iron angle-piece, *F*, and then held firmly in their places by being tightly fixed on to the platform with a stout thumbscrew. Thus the whole can be put together and easily taken to pieces for portability, and packed into a small space. Should the posts be found not sufficiently rigid with one angle-iron, use two—one on each side. On the top of each post, drive in a long screw with a small head. These support the curtain-pole, the latter having holes drilled through it or burnt with a hot iron rod. The same proceeding serves for the roller, which is fixed to the top of the scene.

The lower part of the scene must have an ordinary blind-lath glued or tacked on to it so that it hangs flat and taut. It will be seen in the illustration that the blind is on a roller which has a metal pin of sufficient length at each end, which is held in its place as shown at *G*. A single cord running round the roller allows it to be raised or lowered for the performance. When the curtain is raised, a blind-lath is to be attached to the lower part of the blind, which will make it hang level and flat on the platform when it descends. The cord is tied on a hook fixed into platform at *H*. The fit-up, if properly made, will be found so light and manageable that the whole structure can rest upon two chairs as shown. A double cord, *X*, secured by a flat-headed nail, and tied to the legs of the chairs, will make all secure and firm. A third chair, for the manipulator to stand upon when working the figures, is placed in the center. Of course, chairs need not to be used, as boxes of a suitable height will serve equally well; but chairs are here suggested as giving about the right height so that the view of the spectators, whether sitting or standing, shall have the right point of sight.

In the event of a garden-party performance, a couple of wooden stakes driven into the ground for the cord *X* to be fastened to will make it more secure in case there may be a slight breeze. No artificial light will be required for the garden performance unless it takes place at night. As an illuminant for the show at night, three candles at each side of the proscenium, as seen in Fig. 2, will be found sufficient. Cut a piece of wood about 1 inch thick (see Fig. 3), 6 inches wide in front, at *A*, and 4½ inches at the back, the sides to be 2½ inches. Then twelve small French nails should be carefully driven into the above wooden base—four for the reception of each candle. Next procure a piece of tin about 7 inches in height, and bend it as *B*. This must fit around the back and sides, and be held in its place by the aid of stout tin-tacks. Next cut a strip of tin 1½ inches wide, and secure it along the front at *A* and around the sides, as shown by the dotted lines, with tacks. Then the illumination is ready. It must here be observed that the object of the narrow slip of tin is to prevent any overflow of grease on to the platform.

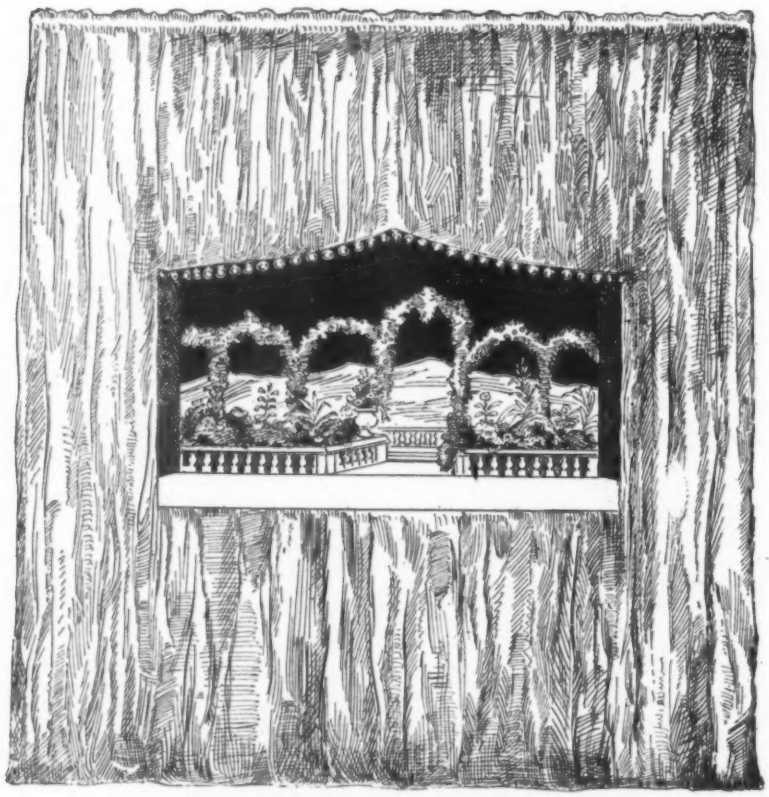


FIG. 1.—A PROFILE PUPPET-SHOW.

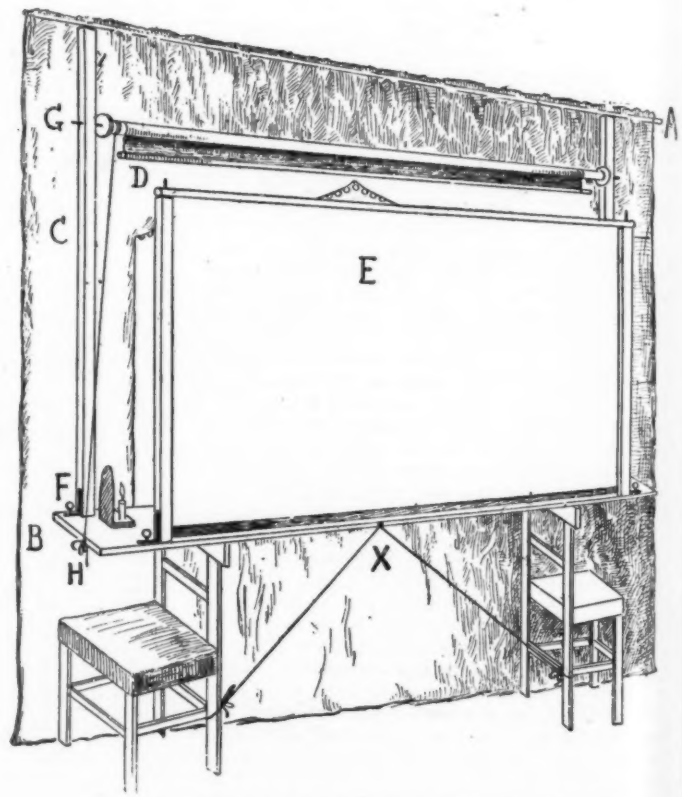


FIG. 2.—CONSTRUCTION OF PUPPET-SHOW SET-UP.

The platform, or stage, may be painted a medium-toned green, or covered with green baize—the latter for preference. The scene may be painted in water-colors on stout cartridge-paper, in distemper on calico, or oil-painted on American cloth—this being the strongest. A scene should be drawn and painted similar to the one shown, with floral arches, etc.; the sky, or where the sky should be, to be painted a dead black—this and the general design tending to hide threads which support the puppets. The curtain, by

(To be continued.)

Leon Guillet's and Ch. Griffith's experiments on the cementation of iron by pure carbon show there is no cementation if precautions are taken to prevent the presence of gases, but it takes place if contact is insured. Moreover, it increases with the pressure, but always occurs extremely slowly.

* English Mechanic and World of Science.

NEW ELECTRICAL AND PHYSICAL APPARATUS.*

INGENIOUS APPLICATIONS OF NEW AND OLD PRINCIPLES.

A NEW ROENTGEN TUBE OF INTENSE ACTION.

A FORM of Roentgen tube which exerts an unusually intense action has been invented by Seitz. In all Roentgen tubes (Fig. 1) the cathode rays, which are discharged by the cathode with very great velocity, impinge upon a metal plate, called the anticathode,

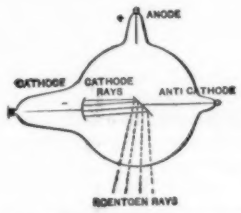


Fig. 1.—Ordinary Roentgen Tube.

where they cause molecular shocks which give rise to the short and irregular pulsations in the ether which constitute the Roentgen or X-rays. In the ordinary Roentgen tube the anticathode, which emits these rays, is entirely inside the glass tube and consequently, as their intensity diminishes in proportion to the inverse square of the distance from the source, the strongest part of their field of action is inaccessible. In Seitz's apparatus (Fig. 2) the anticathode forms part of the wall of the tube and is not inclosed in glass, and the rays employed are those which pass through the anticathode and are emitted by its external surface. Hence, in order to give the anticathode great permeability, combined with great radiating power, it is composed of three layers of different metals: aluminium on the inside, copper in the middle, and platinum on the outside. It is kept cool by contact with an annular vessel of water, to which

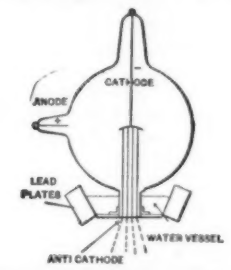


Fig. 2.—Seitz's Roentgen Tube.

radiating plates of lead are attached. The apparatus is designed less for penetration than for the concentration of very intense radiation on a small area.

A NEW ELECTRIC CURRENT METER.

When a solution of a salt of silver is decomposed by an electric current, the quantity of silver deposited on the cathode (Fig. 1) is proportional to the strength of the current and the duration of its flow. The same law applies to the electrolysis of solutions of other metals, the quantity of metal deposited by a given current in a given time being the same for all salts of the same metal, but different for different metals. For example, a current of 1 ampere deposits, each second, 0.001,118 gramme (about 1/60 grain) of silver, or 0.000,328 gramme (about 1/200 grain) of copper.

Numerous instruments based on this principle have been devised for the measurement of the amount of

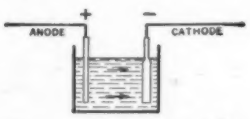


Fig. 1.—Electrolytic Cell.

current, or of electric energy, furnished to consumers. The Stia current meter, made by the Schott company of Jena, Germany, is one of this class, which lays especial claim to reliability and certainty of operation. The electrolytic cell (Fig. 2) is a closed glass vessel of peculiar form, which is divided into a large upper and a small lower compartment by a cylindrical diaphragm composed of glass rods, which rests upon a conical elevation of the wall of the vessel. The lower compartment and the upper part of the upper compartment communicate freely through the interior of the hollow cone and cylinder, and both are filled with a solution of iodide of mercury. The annular space at the bottom of the upper compartment, surrounding the glass cone and cylinder, is kept filled to a constant level with mercury, after the manner of a siphon ink well, by its communication with a lateral reservoir of mercury. The mercury and the solution of iodide of mercury are in contact through the interstices between the glass rods, but capillary action prevents the mercury from flowing between the rods and down into the lower compartment. The mercury

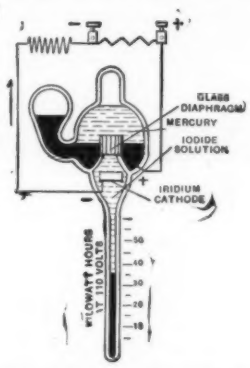


Fig. 2.—The Stia Current Meter. (Vertical Section of Cell and Diagram of Connections.)

serves as the anode of the electrolytic cell. The cathode is a thin plate of iridium which is suspended in the iodide solution in the lower compartment. While the current flows, mercury is deposited at the cathode, and an equal quantity of mercury is dissolved from the anode. The mercury separated at the cathode flows down into the narrow graduated tube below. The level of the mercury in this tube, therefore, indicates the total quantity of electricity that has passed through the meter. When this tube becomes filled, the

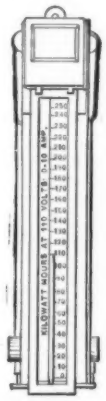


Fig. 3.—External Appearance of Meter for House Service.

number of ampere hours which corresponds to its total capacity is recorded, and the apparatus is made ready for further use by the simple process of tipping it in such a manner that all the mercury flows into the lateral reservoir.

In order to avoid the necessity of repeating this operation at short intervals, the meter is connected, not with the main circuit, but with a shunt of such resistance that only a small and definite proportion of the current flows through the meter. In order to keep this proportion constant and independent of variations in the temperature, and consequently in the resistance, of the electrolytic cell, the shunt resistance is composed of substances which have an aggregate temperature coefficient of resistance equal to that of the electrolyte.

In external appearance the small Stia meter, designed for use in private houses, closely resembles an ordinary thermometer, as the small graduated tube is the only visible part of the apparatus (Fig. 3). This meter, like all of its class, can be used only for direct, and not for alternating currents.

A NEW ELECTROSCOPE WITH QUARTZ FIBERS AND MICROSCOPIC READING.

Very great improvements in the construction of electrometers have been made in the last few years. One

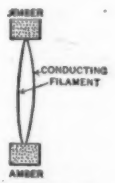


Fig. 1.—Wulff Electrometer.

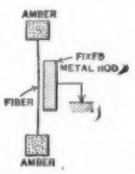
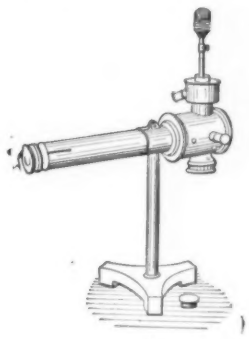


Fig. 2.—Lutz Electrometer.

of the new instruments is Wulff's electrometer, in which the mutual repulsion and displacement of two parallel fibers of quartz, rendered conductive by a coating of platinum, are observed by a microscope. In the very practical instrument of Lutz-Edelmann, the repulsion is exerted between a single quartz fiber and one or two fixed metal rods.

The newest electrometer, the invention of Prof. Wiechert, shows a very notable improvement in the method of reading. The electrical part of the apparatus consists essentially of two platinized quartz fibers, which are attached by one end to the top of a metal post, having an insulating base of amber. The fibers, when not electrified, point obliquely downward and rest against the inclined sides of the support, but upon being electrified, they spread apart and turn upward. The displacements of both fibers are observed simultaneously by means of an ingenious optical device. Before each of the fibers is a lens and a reflecting prism, so contrived that the images of the two fibers are brought together. In this position the images intersect, and the point of intersection is read by means of a vertical scale and a single eye lens. According to the size and stiffness of the fibers, the range of the instrument may be varied from fifty to four hundred volts for one hundred scale divisions. The electrostatic capacity is 6.8 centimeters.



3. 4.

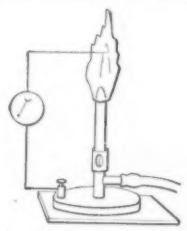
Fig. 3.—Wiechert Electrometer. Fig. 4.—Arrangement of Fibers in Wiechert Electrometer.

5. 6.

Fig. 5.—Diagram of Wiechert Electrometer. Fig. 6.—Crossed Images of Fibers.

ELECTRICITY OF FLAMES.

Chiarini has discovered that, if the base of a Bunsen burner is connected by a platinum wire with the hottest part of the flame, an electric current of about 2 millionths of an ampere flows through the wire, the ends of which show a difference of potential of fully 1 volt. The circuit formed by the burner, the flame,



Electricity of Flames.

and the platinum wire exhibits unipolar conductivity, or allows the current to pass in one direction only. This circuit may, consequently, be employed as an electric valve, or rectifier, for alternating currents.

Some idea of the general use of false teeth may be gathered from the statement that 20,000,000 of them are exported from America to England every year. When we consider that probably not more than half the inhabitants of Great Britain indulge in the luxury of false teeth, no matter how many grinders they may have lost, these figures would seem to indicate that nearly everyone in England suffers from defective or missing teeth. As far as observation goes, the United States is no better off than England in this respect.

* Prometheus.

THE MICROSCOPE AND THE SCIENTIST.*

SOME APPLICATIONS OF MICROSCOPY TO MODERN SCIENCE.

THE time is past when a man can expect to make any real contribution to knowledge by spreading his observations over the whole vast range of microscopic objects. In these days, in which the output of research on every subject is enormous, and is increasing rather than diminishing, a man is more likely to make progress and do useful work by taking up a special line and sticking to it. Speaking for those who work *with*, rather than *at*, the microscope, I would advise everyone who wishes his work to be fruitful in results to have a hobby of his own. In making the suggestion, I do not mean that we are all to become narrow specialists, interested in nothing but our own particular subject. Specialization in work and in research does not necessarily mean specialization in knowledge or in interests. The great value of such a club as ours is that by bringing together people occupied in different branches of work it enables one man to know what another man is achieving in a different line, thereby at once widening his outlook and stimulating him in his own work by producing a healthy spirit of emulation.

My advice, therefore, to the microscopist would be that he should aim at wide knowledge and diffuse interests, but should concentrate his activities and focus his attention on his own particular pet hobby, so that, by mastering a branch of natural knowledge, he may find himself in a position to advance it. However limited the field of study may be, however insignificant the objects may appear, yet something can always be found which, on the one hand, will illustrate some important and fundamental principle, or, on the other hand, will prove ultimately to have some direct or indirect bearing on human life and its needs. Let me give two instances in support of this statement. To the so-called practical man it may seem a very trivial occupation to worry about such things as Foraminifera, however beautiful their shells may be. Yet these tiny creatures, living in a sphere apparently so remote from our own, furnish wonderful illustrations of the powers and activities of primitive living matter, and Mr. Earland has recently directed our attention to the remarkable property they exhibit of selecting particular materials for building up their houses. This is a most interesting fact, well worthy of further study, especially by experimental methods, for it indicates that the most primitive and formless living matter possesses faculties of a kind which we term in higher forms of life instinct or intelligence. Again, a reputation for being an expert on, let us say, fleas, may provoke a smile from the uninstructed; but in view of the proved connection between fleas and human disease, especially plague, these paltry insects have now assumed very great importance as objects of study, and we find detailed descriptions of them in the reports of government commissions. As Lord Crewe remarked in a recent speech, we commonly speak of any very trivial annoyance as a flea-bite; but we know now that in certain circumstances a flea-bite may cost a man his life. Small wonder, then, that fleas have become important objects of study to mankind.

This question of fleas and plague reminds me that I am here, not to preach a sermon, but to give an address, by recalling to my mind the subject which I propose to discuss to-night, namely, some of the remarkable advances that have been made during the last few years in our knowledge of human diseases caused by microscopic parasites. This is a subject which has now grown to such vast proportions that I must confine myself of necessity to a small part of it, namely, the diseases caused by Protozoa. As examples, I shall deal more especially with malaria, sleeping sickness, and yellow fever.

Malaria is a disease which was well known to the ancients, and is still very rife in many parts of Europe. It appears to have been prevalent formerly in the fen districts of England, but to have died out there from some unexplained reason. It is estimated by Prof. Ronald Ross to cause from a quarter to half the total disease in the tropics. It occurs under at least three forms, known commonly as tertian, quartan and pernicious malaria, each of them easily distinguishable clinically, and due to distinct species of the parasite differing from one another in morphological characters, but similar in the general features of their life-cycle.

Until comparatively recent times nothing whatever was known of the nature of malaria or the manner in which it was acquired. It was generally believed that it was due to a poisonous miasma which arose from swamps and marshes, a notion conveyed in the name malaria—"bad air." This miasma theory is very prevalent in literature; for instance, in such a work as Dickens's "Martin Chuzzlewit," where the unfortunate settlers in Eden are supposed to contract fever by breathing the exhalations of the swamps.

The scientific study of malaria may be dated from 1880, when the parasite was discovered in the blood of fever patients by Laveran, then a military surgeon in Algiers. Laveran examined the blood microscopically, and observed the principal phases of the parasite. It was, however, some years before Laveran's parasite was accepted as the cause of malaria, though it ultimately obtained universal recognition. Even then it remained a mystery how the parasite got into the blood, and many still held to the miasma theory. It was supposed by some that the parasite passed out of the body and produced cysts or spores which could be disseminated by the wind, just as the cysts of many infusoria are known to be carried by aerial currents, and that by inhaling these air-borne germs the disease was acquired. Others sought for the source of the infection in the contamination of drinking-water.

It remained for a countryman of ours to discover the true method of infection. Prof. Ronald Ross, then in the Indian Medical Service, experimented first with the very similar malarial parasites of birds, and found that the infection was taken from one bird to another by mosquitoes of the genus Culex. Similar experiments on human malaria gave at first negative results, until it was discovered that the necessary intermediate host of human malaria was a mosquito belonging to quite a different genus, Anopheles. These experiments were confirmed by many investigators in all parts of the world, and led to results which may be stated in two propositions, one positive, one negative, first premising that by a malarial infection is meant a new infection, not a relapse in a person previously infected.

(1) Malaria can be and is conveyed from sick to healthy persons by the agency of mosquitoes.

(2) Malarial infection is not known to take place by any other method.

Experiments further showed, as I have mentioned already, the very remarkable fact that avian malaria can only be transmitted by culicine mosquitoes, and human malaria only by anopheline. If human blood containing the parasite be taken up by a Culex, the parasite cannot develop, but is digested up, along with the blood. The same thing happens to the parasite of avian malaria when taken up by an Anopheles.

Following on these experimental discoveries, the development of the parasite was studied microscopically in all countries by a great number of observers, among whom we may mention especially Grassi in Italy and Schaudinn in Germany. By their combined labors the complete life-history of the parasite has been worked out in the greatest detail, revealing one of the most fascinating chapters in natural history.

(An account was then given of the development of the malarial parasite, illustrated by a diagram.)

My second example, sleeping sickness, is also a disease that has been long known, though without attracting, until recently, so much attention as malaria. It was first observed in the West Indies in negro slaves imported from the west coast of Africa, the region in which it appears to be endemic. It was observed that the negroes suffering from it were not infectious, and that the disease did not spread to others—a fact easily explained by what is now known about the transmission of sleeping sickness, namely, that it is effected by flies of the genus Glossina, commonly known as tsetse-flies, which are confined at the present time to the African continent.

Of recent years this previously obscure disease has forced itself on the public attention by its having spread from its native haunts on the west of Africa and invaded regions previously free from its presence. In our protectorate of Uganda, in particular, it has caused terrible mortality, completely extirpating the natives in some parts, and numbering also many Europeans among its victims. I do not propose here to enter into the distressing symptoms of this deadly disease, but only to deal with what may be termed its natural history.

Before it is possible to understand clearly the nature of sleeping sickness it is necessary to say a few words about similar diseases in animals. It was well known to all African travelers from the time of Livingstone that domestic animals, especially cattle, horses, and dogs, were liable in Africa to a peculiar fatal disease known as nagana, caused by the bite of blood-sucking flies of the genus Glossina, the tsetse-flies, of which there are several species abundant in various parts of Africa. It was supposed that the fly produced and injected a virus which caused the disease.

The nature of nagana was first made clear by Sir David Bruce, who found that the cause of the disease was the presence in the blood of a minute flagellat or trypanosome, since named *Trypanosoma brucii*, and that the tsetse-fly did not generate the parasite, but was merely the unwitting agent in transmitting it from infected to healthy animals.

When the epidemic of sleeping sickness broke out in Uganda, the Royal Society, at the request of the government, appointed a commission to investigate it, and Sir David Bruce was sent out as a member of the commission. A trypanosome was found by Castellani in the cerebro-spinal fluid of sleeping-sickness patients, and it was shown by Bruce and his assistants that this trypanosome was the cause of the disease, and that it was transmitted from sick to healthy persons by the bite of the local species of tsetse-fly, *Glossina palpalis*. It was proved by subsequent researches that the trypanosome causing sleeping sickness was identical with one that had been discovered previously in the blood of negroes in Gambia, and named *T. gambiense* by Dutton. In short, it was proved that sleeping sickness of man is a trypanosome disease similar to nagana of animals, but produced by a different species of trypanosome, transmitted by a different species of tsetse-fly, and running a somewhat different course. Whereas *Trypanosoma brucii* remains in the blood of its victims until their death, *T. gambiense* is found in the blood in the early stages of the disease, but spreads, probably through the lymphatic channels, into the cerebro-spinal fluid, and then causes the peculiar nervous symptoms which give the disease its name. The rapid spread of sleeping sickness into regions where it was previously unknown is an indirect consequence of the occupation of the African continent by European Powers. Formerly the native tribes were constantly at war with one another, and a negro never traveled any great distance from his own village. Now caravans move in every direction, and doubtless in this way the disease has been spread by porters and other natives already infected with the trypanosome coming into regions where tsetse-flies abound, and there infecting the flies, which in their turn have disseminated the infection among the previously healthy population.

Although it was proved experimentally that the disease is propagated by tsetse-flies, the exact method by which this is effected has remained hitherto somewhat mysterious. It was proved that the infection could be conveyed by what may be termed the direct mechanical method; that is to say, if a fly has sucked recently the blood of an infected person, its proboscis may contain living trypanosomes, and if it inserts its proboscis, immediately or a short time afterward, into the skin of a healthy person, it may convey the infection simply by means of its contaminated proboscis. Experiments showed that infection in this direct manner only took place up to forty-eight hours after the fly had fed on the infected subject, and all attempts to obtain infection with flies at a longer interval than forty-eight hours gave negative results. Experimental evidence was therefore lacking for the existence of a developmental cycle of the parasite in the fly, although it was argued by many writers that for various reasons such a cycle must exist. Quite recently, however, a positive result has been obtained by Prof. Kleine, director of the German Sleeping Sickness Commission in German East Africa. Experimenting with nagana by feeding a batch of flies first on an infected animal and then on a long succession of healthy animals, he has made the most interesting and important discovery that the flies are not infectious at all until some three weeks after their first feed, and that then they infect every animal upon which they are fed. This result indicates that the incubation period—that is to say, the time occupied by the parasite in its cycle of development in the fly—is far longer than anyone had suspected, and that the negative results of former investigators are to be explained by their experiments not having been extended over a sufficiently long period. It must be borne in mind that to those working in tropical Africa it is often difficult, or even impossible, to obtain a sufficient number of experimental animals for such a protracted series of experiments.

From Prof. Kleine's experimental results it is evident that the trypanosome of nagana, and doubtless of sleeping sickness also, does undergo a cycle of development in the tsetse-fly, and the way is now open for the microscopist to rush in and to observe what becomes of the parasite in this long period that elapses between its being taken up by the fly and being given out again. We may expect that a fascinating and wonderful history will be made known of the transformations and migrations, the amours and the in-

* From the presidential address delivered to the Quekett Microscopical Club on May 7, 1909, by Prof. E. A. Minchin.

crease of the trypanosome in the bowels of the unconscious tsetse-fly; and we seem now to be in sight of a solution to the baffling problem of the transmission of diseases caused by trypanosomes.

The third disease I have chosen for my discourse, namely, yellow fever, is one sufficiently well known to everyone, by repute at least. There is no need for me to describe at length the dreaded "Yellow Jack," a malady often fatal, and always excruciatingly painful. The connection of this disease with mosquitoes has long been suspected, and has recently been proved conclusively by both the American and French commissions sent out to study the disease. The mosquito in this case is neither a Culex nor an Anopheles, but one belonging to a distinct genus, namely, *Stegomyia fasciata*, sometimes called the tiger-mosquito. It has been proved conclusively that the mosquito does transmit yellow fever, and it has also been proved that the disease is not communicated by direct infection or contagion through contaminated clothes or dwellings; and here let me direct attention to one great obstacle to conducting experiments in yellow fever—the fact, namely, that the disease is not communicable to animals, but only, so far as is known, to man. Hence experimental studies on the disease could only be performed on men who offered themselves voluntarily for this purpose. Such experiments were sometimes negative, sometimes positive, in their result; in the latter case, of course, the subject of the experiment acquired the disease, and in one case, at least, died of it. It would require the pen of a Shakespeare or a Milton to do adequate justice to such devotion on the part of these brave men to the cause of science and humanity.

By numerous carefully devised experiments a number of important facts relating to the transmission of yellow fever were elicited. It was shown that the unknown cause of the disease is in the blood of the patient only during the first three days of the illness, so that only during this period can mosquitoes become infected by sucking the blood of the patient. Consequently, if the patient be protected from mosquitoes for the first three days he ceases to be a danger to the community as a source from which the infection can spread. It was shown, further, that the mosquito, after acquiring the infection, goes through an incubation period of from twelve to fourteen days, during which it is not infectious; but after that it is infectious for the rest of its natural life; and a further point of interest was added by the French commission, namely, that an infected mosquito may transmit the infection to its offspring, so that a mosquito which has never fed on an infected person may be congenitally infectious.

I have chosen the instance of yellow fever to put before you because, although we have now such an accurate knowledge, gained by experiment, of the cause and transmission of the disease, no one has succeeded as yet in seeing the parasite itself. It is practically certain, for many reasons, that there is some minute parasite at work, and there are grounds for suspecting that the parasite is a spirochæte, one of those minute, actively flexible, thread-like organisms of which the affinities are so much in dispute at present, and which some authorities class with the Protozoa, others with the Bacteria; but here we have a case where the microscopist has been baffled, and where we get beyond the present limits of the powers of our instrument, a fact which should make us appreciate the labors of those who study the microscope and strive to perfect it.

Did space permit, I might mention many more important discoveries in the field of protozoan parasites causing disease. For example, there are the blood parasites of the genus Piroplasma (Babesia), causing fatal forms of hæmaglobinuria in various animals; they are not yet known for certain in man, but a species is known from monkeys, a source which is getting perilously near to us. Here the agent of infection is a tick of some sort, and usually the infection goes through two generations of ticks, being transmitted from the mother-tick, which has acquired the infection, to the numerous progeny of minute six-legged tick-larvæ, which in their turn infect the vertebrate host. Then there are the relapsing fevers caused by spirochætes in the blood, and said to be transmitted in Europe by bed-bugs, but in Africa by a species of tick which lives in mud floors. In India and other parts of the tropics we find that the deadly disease known as kala azar, due to a parasite, is transmitted in all probability by bed-bugs. All these and many others furnish points of great interest, but I must be content with the three examples with which I have dealt in more detail, in order to show you how great a work has been done and is being done in this field. As Prof. Osler said recently, these discoveries are going to have an enormous influence on the history of the world and of mankind, because they are going to make the tropics habitable by white men. We hear or read so often of such-and-such a country being uninhabitable by Europeans on account of its deadly climate; but when we look into the matter we find that it is not the climate at all that is to blame, but that the whie races are killed off by diseases caused by some animal parasite with which they are inoculated by the bite of some bloodthirsty arthropod. Take Uganda, for instance, with which I have a slight acquaintance; all that the climate does for you there is to give you a sunstroke if you go out in the heat of the day with inadequate headgear, and to make it very difficult to keep awake after lunch. Some well-known European infectious diseases, such as small-pox, are also rife there; but, on the other hand, some of our familiar plagues, such as tuberculosis, rheumatic fever, and influenza, appear to be absent. The diseases that are really to be feared are all such as spring from bites of arthropods. If you protect yourself from the mosquito you will not get malaria; avoid the tsetse-fly, which is very easily done, and you are safe from sleeping sickness; do not sleep on mud floors, nor pitch your tent on old encampments, and relapsing fever will not trouble you; keep rats and fleas at a distance, and you are safe from plague. With a little care and attention to surroundings the European finds his life in the tropics, if anything, more free from disease than in our temperate but influenza-ridden Palæarctic climate.

In the foregoing remarks I have directed attention more particularly to the practical results of microscopy wedded to sagacious experiment, and have tried to show how fertile in good results this union has been, and promises still to be; but I would not have you go away with the impression that I advocate such studies solely on account of immediate practical good to be derived from them. Far from it. I am one of those who hold so-called theoretical and unpractical studies to be of the highest importance, and worthy of all support, if only for the reason that, being unremunerative, they often cannot support themselves. All history shows us that the knowledge of general principles must precede their application and practice, and that what is purely theoretical in one generation becomes thoroughly practical in the next or in a later one. There is no need for me to waste your time by multiplying instances of this familiar truth; but I will conclude with a few words on the wider applications of microscopy.

In the range of the natural sciences, two branches of knowledge stand at opposite poles, as judged from the standpoint of the objects with which they deal. The science of astronomy deals with the infinitely great; the science of biology, on the other hand, with the infinitely small. The astronomer with his telescope astounds us with the distant worlds he reveals to us; he thinks in millions of miles as ordinary persons deal with feet or yards; and he exhibits to us this world on which we live as but an insignificant planet, one of many, whirling round a star far inferior in magnitude to many of those we see nightly, a tiny speck in the vast ocean of space and matter, peopled by a race of puny creatures who style themselves the lords of creation, although their dominion does not extend over a billionth part of the universe. "The consciousness of an endless series of worlds," said Kant, "destroys my sense of importance, making me only one of the animal creatures which must return its substance again to the planet (that, too, being no more than a point in space) from whence it came, after having been in some unknown way endowed with life for a brief space."

Not less astounding, but in a totally different way, are the revelations of the biologist with his principal instrument of research, the microscope. With this he discovers continually new worlds invisible to the unassisted eye, and reveals infinite complexity in things apparently the most simple. We find, in the first place, our own bodies to be microcosms, small worlds, that is, of such inexhaustible variety and elaboration of detail that to the human mind they are as difficult to comprehend and to realize in their entirety as the macrocosm or great universe itself. We find, further, that each human body, itself appearing as a single individual or unit, is in reality made up of many billions of living units or cells, each as much a microcosm as the whole body; and thus our instrument, the microscope, brings us face to face with the greatest mystery in the whole range of the sciences, namely, the problem of life and living matter. There is, apparently, no gap in nature so profound as that which separates the living from the not-living. The nature of life, its origin and destiny, the laws that govern living matter and vital processes of all kinds, these are of all problems not merely the most fundamental in science and philosophy, but also the most important for our practical knowledge and daily conduct.

It would be futile to assert that human science has as yet made any great advance in elucidating the nature of life. On the contrary, all progress in research only throws into greater relief the difficulty of the problem; the better we become acquainted with it, the more the mystery deepens. Nor would it be right to assert that the microscope is the sole instrument of research in this field. Our knowledge of the properties and activities of the living substance and of living things advances daily by leaps and bounds through methods of investigation in which the microscope plays no part. I have referred to the knowledge that has been gained of the life-history of the parasite of yellow fever, in spite of the fact that the microscope has failed completely, so far, to detect the parasite itself. But we may safely claim that the greater and most important part of modern biological knowledge could not have been gained without the instrument which it is the object and purpose of our club to study, to perfect, and to apply; and, further, that to be able to see the objects with our own eyes makes them much more real and true to us than merely to infer their presence and properties from experiments in the dark, so to speak. "Seeing is believing" is an English proverb which has its counterpart in all languages. We may be satisfied in our minds as to the existence and behavior of the yellow-fever parasite, but nevertheless its discovery by optical means would be greatly welcomed as an important advance in our knowledge.

There is no greater stimulant to the all-important study of living things than the feeling of wonder and delight which the first sight under the microscope of objects otherwise invisible produces in even the most uninstructed mind. Most of us probably can date our first interest in minute living objects from the time when, perhaps in early youth, we were given, or allowed to use, a microscope, with which we could gratify, without satisfying, our curiosity in looking at all kinds of minute objects. In such an occupation the appetite comes with eating, as the French proverb says, and the instrument which was at first a fascinating toy leads us on until, one might almost say, it masters and enslaves us. In this development there is another instance of the parallel between the progress of the individual and the history of the race. To the majority of early microscopists the microscope was but a toy, an instrument which competed with the magic-lantern as an amusement for drawing-room séances, and only a serious minority made use of it as a means of earnest scientific investigation. There are, perhaps, still microscopists whose chief delight is to thrill their friends, especially those of the fair sex, by the sight of hairs on a spider's leg, or the elephantine proportions of a cheese-mite. If so, let us not scoff, as some do, at the amateur; we ought rather to regard him with the same interest that a zoologist looks on an okapi or a lepidosiren, as a living representative of a bygone age. For the modern microscopist is fearfully in earnest, and has but little opportunity for amusement in pursuing a science which taxes not only his brain, but his eyes to the utmost. There is scarcely any greater physical strain than the long-continued investigation carried on with the highest powers of the microscope, and in my own experience I have known some who lacked the physical endowment for such work, and others who have been obliged to retire from the field. Let us, then, in a pursuit which but too frequently dulls enthusiasm by fatigue and exhaustion, in which our "native hue of resolution" tends to become "sicklied o'er by the pale cast of thought," rather envy those who retain the freshness of their early delight, and strive to cultivate, rather than to stifle, that feeling of wonder and curiosity which should be the starting point of all philosophical and scientific investigation. "Two things," said Kant, "fill my mind with ever-renewed wonder and awe, the more often and the deeper I dwell on them—the starry vault above me and the moral law within me." I venture to think that had Kant lived in our days he would have found a third source of wonder in the contemplation of the simplest living things as revealed by the microscope, in the combination they present of apparent simplicity with infinite complexity, and of extreme minuteness with the most extraordinary powers. To me the observation of a minute organism, such as amœba, under the microscope, is in its way as marvelous as the sight of the starry firmament. I see a minute, formless creature, without definite parts or organs, which nevertheless exercises all the functions of life and exhibits the germ of every faculty we possess, and thereby proves that its apparent simplicity and formlessness cloak a complexity of organization far transcending our powers of observation and eluding our means of detection. What, again, can be more wonderful to contemplate than the fact that peculiarities in the complex mental endowment and physical structure of a human being can be transmitted from one generation to the next through the medium of spermatozoon, the tiniest cell of the human body, in which the microscope reveals only a structure of the simplest kind? These things must rank with the most wonderful and inexplicable of the phenomena that nature presents to us, and we are as yet only on the threshold of investigation. The stellar universe has been observed, its laws and motions studied, for many thousands of years, but our acquaintance with the beginnings of life and its properties as exhibited by the simplest living things is but an affair of yesterday, as it were, and the scientific study of life is as yet in its infancy.

In these days of vast and rapid increase of knowledge in such matters there is danger that we may lose

the true perspective, and that our perception of the whole may be blunted and obscured by the immense mass of detail which forces us to attend only to a small part of our science. It is the special function of a club such as ours to keep fresh our enthusiasm and to enlarge our outlook by contact and intercourse with those working in other fields, to spread the infection, if I may use the term, of intelligent curiosity in the minutest natural objects, and thereby to attract and enlist new workers in a field in which the harvest is plentiful but the laborers are few.

ENGINEERING NOTES.

In the south of France there is a concrete arch bridge known as the Pont du Gard, which was erected in the year 56 B. C. The concrete in this was not composed of crushed stone or other small aggregate of the variety now employed in concrete bridge work, but was of the old style, consisting of alternate layers of large and small stones, gravel, etc., and of cementitious materials. Vitruvius describes the materials and methods in use before the Christian era, and other writers like Alberti in 1845, and Palladio in 1570, accurately describe the method which the "ancients" employed "of using boards laid on edge and filling the space between with cement and all sorts of small and large stones mingled together." It is very improbable that the Pont du Gard would have withstood the rigors of a severe climate, but its actual state of preservation, as well as that of many other specimens of ancient concrete work, proves that if modern work is honestly executed it lasts a great number of years, so that a very small yearly sinking fund per cent is all that is required for properly designed and erected concrete work.

Although it is possible to resolve into gas almost any kind of solid fuel in a gas producer, it is well known that certain fuels—particularly those high in ash and of a caking character—give a good deal of trouble. One of the most serious of these troubles, states a contemporary, is that the fuel welds itself into a large mass, which partially chokes the fire in some places and causes passages or holes to be burnt at others. Hence poking of the fire is necessary, and the poorer the fuel the more the poking. In order to reduce this poking to a minimum, some producer makers fit shaking or revolving grates. The latest design of this character is due to Mr. Chapman, an American, and it is a considerable extension of the principle. The lower portion of the producer is divided into two or three rings, which are free of each other and rotate at different speeds, the joints between them being made by water seals. The object is to shake the fuel continuously, so that caking or clogging and holes are equally impossible.

At a recent meeting of the Transvaal Institute of Mining Engineers, Sir Thomas Price made some interesting remarks concerning the relative merits of American and British locomotives. The policy of many, if not most of the American railways, he said, was to get the very utmost work out of the engine as soon as it got out on the open lines, because they were aware with the constant forward movement of locomotive improvements that the engine which was in the very front rank to-day, in a few years became obsolete, because of the improvement continually going on. Consequently, the American practice was to get the very utmost out of the engine and then scrap it. That being the case, it naturally did not receive the attention and the especial care that was paid to the English engine. It was a question whether the American or English practice was the better. Their experience in South Africa was that something between those two methods was the better; he would not say the mean was the better, but the best of the American practice and the best of the English practice was what they found to answer best.

A steam boiler and furnace of peculiar construction, which requires no chimney, because the combustion gases are mixed with the steam which is admitted to the cylinders of the steam engine, have been in successful operation for some time on a Russian torpedo boat. The apparatus is the invention of a Russian naval engineer named Schmidt. Liquid fuel is used, and the combustion gases, which have an initial temperature of from 3,300 to 3,600 deg. F., have a temperature of about 1,800 deg. F. when they leave the heating surfaces of the boiler. The gases then enter a tube into which a fine spray of cold water is injected under pressure. The gases are thus cooled to between 650 and 900 deg. F., and the water is converted into superheated or unsaturated steam of the same temperature. The mixture of steam and combustion gases is conducted into the upper part of the boiler and flows thence, mixed with steam generated in the boiler, to the cylinders. In addition to dispensing with the chimney, the new boiler possesses the merit of very high efficiency, utilizing 90 and even as much as 97 per cent of the heat produced by the combustion of the fuel. Smokeless combustion, which is easily obtained with liquid fuel, is essential to the satisfactory operation of the Schmidt boiler.

ELECTRICAL NOTES.

A correction has been made by R. W. Gray and W. Ramsay in the value given for the half-life period of radium. The half-life period is 1,744 years, or in other words, one gramme of radium will have been reduced to five-tenths of a gramme after 1,744 years.

According to the Electrical World, a State report shows that 26 per cent of the 312 cotton mills of North Carolina are now using electricity as the sole motive power. This revolution in the matter of motive power has been achieved practically within the last ten years, especially among the new mills, while probably 60 per cent of the existing mills have been completed during the ten-year period referred to. Furthermore, it is found by comparison of figures that 35 per cent of the cotton manufacturing plants use electricity either entirely or in part. The indications are that this percentage will gradually increase, until practically every up-to-date mill in the South will be electrically driven, unless it is so situated that inaccessibility to electric supply will prevent the change.

The prospects of telephony and high-speed telegraphy through ocean cables are considered by K. W. Wagner in Electrotechnische Zeitschrift. Hitherto alternating currents have been used for telephony and high-speed telegraphy. Mr. Wagner considers the question mathematically, and comes to the conclusion that an alternating source of supply, as distinguished from a continuous source, is not of itself productive of superior results over a long cable, owing to the damping of the current waves and the consequent deformation of the signals. No greater distance can be compassed with alternating than with continuous current. Wagner looks rather to the employment of Pupin coils or other means of increasing the self-induction for the attainment of the end in view.

It is stated in the Electrical Engineer that a wireless telegraph detector has been invented by Mr. J. H. A. Pike of Arncliffe, New South Wales. By its use, and with wires at a height of 50 feet, Mr. Pike has been enabled to interpret messages flashed by H. M. S. "Powerful" from near Auckland, New Zealand, to the warships lying in Sydney Harbor, a distance of 1,350 miles, after the latter were unable to keep up communication. At various times the inventor has been in communication with shipping at all ports of the Australian capitals, excepting Perth, and confidently anticipates being able to receive messages over a range of 1,500 miles. Messages are recorded telephonically, and can be distinctly heard three feet away from the apparatus. It is claimed for the invention that it is more sensitive and delicate than any other detector known.

CONCRETE
REINFORCED CONCRETE and CONCRETE BUILDING BLOCKS

Scientific American Supplement 1543 contains an article on Concrete, by Brysson Cunningham. The article clearly describes the proper composition and mixture of concrete and gives results of elaborate tests.

Scientific American Supplement 1538 gives the proportion of gravel and sand to be used in concrete.

Scientific American Supplements 1567, 1568, 1569, 1570, and **1571** contain an elaborate discussion by Lieut. Henry J. Jones of the various systems of reinforcing concrete, concrete construction, and their applications. These articles constitute a splendid text book on the subject of reinforced concrete. Nothing better has been published.

Scientific American Supplement 997 contains an article by Spencer Newberry in which practical notes on the proper preparation of concrete are given.

Scientific American Supplements 1568 and **1569** present a helpful account of the making of concrete blocks by Spencer Newberry.

Scientific American Supplement 1534 gives a critical review of the engineering value of reinforced concrete.

Scientific American Supplements 1547 and **1548** give a resume in which the various systems of reinforced concrete construction are discussed and illustrated.

Scientific American Supplement 1564 contains an article by Lewis A. Hicks, in which the merits and defects of reinforced concrete are analyzed.

Scientific American Supplement 1551 contains the principles of reinforced concrete with some practical illustrations by Walter Loring Webb.

Scientific American Supplement 1573 contains an article by Louis H. Gibson on the principles of success in concrete block manufacture, illustrated.

Scientific American Supplement 1574 discusses steel for reinforced concrete.

Scientific American Supplements 1575, 1576, and **1577** contain a paper by Philip L. Wormley, Jr., on cement mortar and concrete, their preparation and use for farm purposes. The paper exhaustively discusses the making of mortar and concrete, depositing of concrete, facing concrete, wood forms, concrete sidewalks, details of construction of reinforced concrete posts.

Each number of the Supplement costs 10 cents.

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SCIENCE NOTES.

According to La France Automobile, Marseilles has lately been the scene of certain trials of the "Fabre" hydro-aeroplane, a machine designed to travel either on water or in the air. This craft, which is driven by a 50 horse-power Gnome engine, has attained a speed of 33 miles per hour as a hydroplane, and in subsequent experiments has risen 6 feet out of the water and continued its onward course in the air for over 500 yards. Within the port itself the "Fabre" has made a flight at a height of 10 feet, and has then been brought gently and quietly to rest on the shore a few feet from the water's edge.

A wine which is non-alcoholic but which contains all the aromatic constituents of natural wine is made in Germany. The manufacture is carried out in three stages. In the first stage the temperature of the wine and the degree of vacuum are so regulated that only the highly volatile aromatic constituents are withdrawn, while the alcohol is not volatilized. The aromatic vapors are conducted through a receiver containing an absorption liquid composed of de-alcoholized wine, grape must and sugar. The first receiver is then cut off, and, in the second stage, the heavier aromatic substances together with a portion of the alcohol and water are distilled over. The vapors of alcohol and water are condensed in a suitable vessel, while the aromatic substances, which are still lighter than the alcohol, are conducted onward through a second absorption vessel. This vessel is next cut off, and the distillation of the alcohol is completed in the ordinary way. The contents of the absorption vessels, charged with the bouquet of the wine, are then mixed with the residue from the still.

A convenient method of refrigeration for analytical and industrial investigations at low temperatures is described by J. O. Handy in the Journal of Industry, Engineering, and Chemistry. Mr. Handy discusses various methods of refrigeration, and gives the preference to the use of carbon dioxide snow with acetone or with petroleum ether. Of these, the acetone mixture has some advantages. The "snow" is prepared by the usual method of allowing the liquid carbon dioxide to blow off through canvas or flannel bags. The temperatures resulting from various quantities of the "snow" with 150 grammes of acetone (at 23 deg. C.) are given as follows: 6 grammes of carbon dioxide, —5 deg. C.; 11 grammes, —20 deg. C.; 24 grammes, —38 deg. C.; 45 grammes, —54 deg. C.; 77 grammes, —61 deg. C.; excess of carbon dioxide, —78 deg. C. With 114 grammes of petroleum ether of 86 deg. B. at 22 deg. C., the temperatures obtained with different weights of carbon dioxide were as follows: 5 grammes of carbon dioxide, 22 deg. C.; 10 grammes, —36 deg. C.; 15 grammes, —55 deg. C.; 30 grammes, —69 deg. C. If absolute freedom from risk of fire is desired, carbon dioxide and carbon tetrachloride or chloroform can be used for a limited range.

W. Fischer has published the results of experiments made for the purpose of separating isomeric chemical compounds by refrigeration. When commercial nitrotoluol, which contains 38 per cent of paranitrotoluol, 60 per cent of orthonitrotoluol and 2 per cent of metanitrotoluol, is cooled, crystals begin to separate at 32 deg. F., and the quantity of crystals increase as the temperature falls. At —0.4 deg. F. a eutectic mixture is formed, and the paranitrotoluol, which melts at 129 deg. F., can be separated by filtration. Nearly all of the para compound can be separated at + 13 deg. F., which is the fusing point of orthonitrotoluol. A similar method of separation is in commercial use in Germany. When a mixture of the three isomeric toluidines is cooled, a solid substance separates at 32 deg. F. At — 4 deg. F. a pasty mass is obtained, composed of crystals of paratoluidine, which melts at 113 deg. F., and a saturated solution of paratoluidine in the liquid mixture of the other two isomers. No separation of the xylols is effected by cooling to — 58 deg. F., but if the mixture is solidified by means of liquid air and is then reheated, the metaxylol melts at — 58 deg. F., the orthoxylol at — 13 deg. F., and the paraxylo. at + 59 deg. F.

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